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GEOARCHEOLOGICAL INVESTIGATIONS AT THE MEMORIAL PARK SITE (36CN164), PENNSYLVANIA

Final Report

July 19, 1994

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Prepared for

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FINAL REPORT

by

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Submitted to

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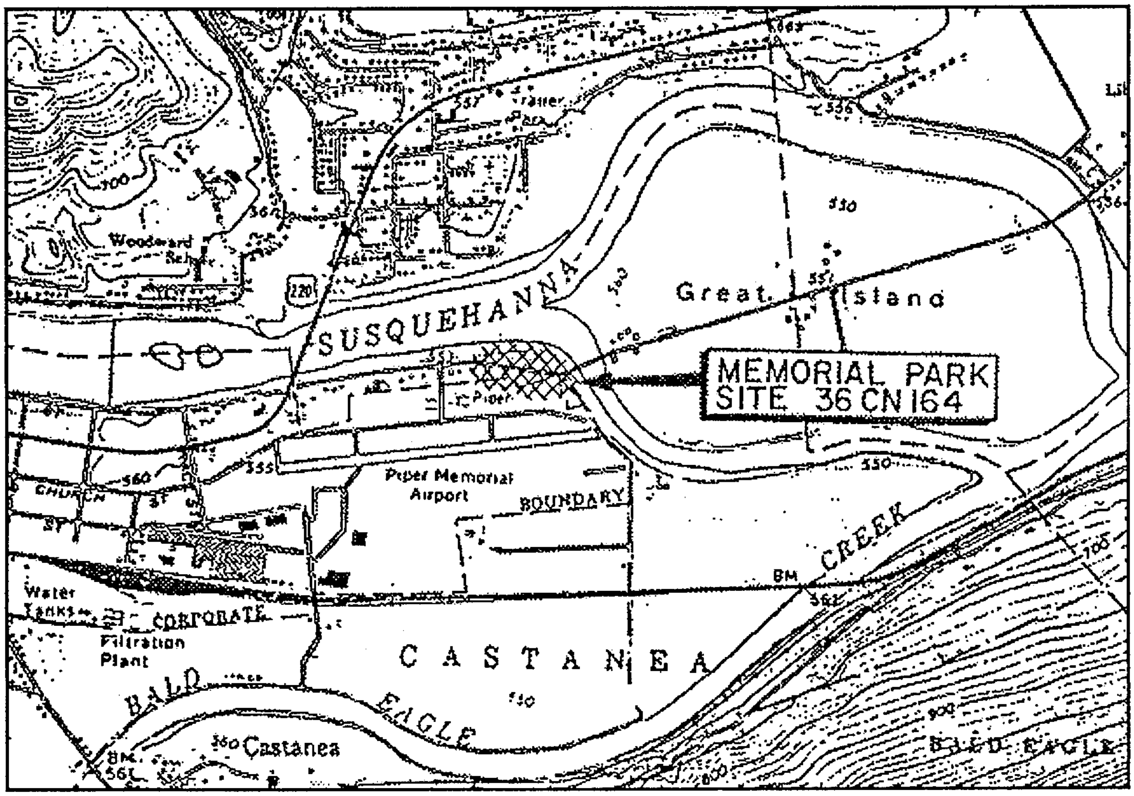
CHAPTER 1: INTRODUCTION

The Memorial Park archeological site (36 CN 164) preserves an unbroken sequence of complex prehistoric occupations in stratified floodplain-terrace deposits of the West Branch of the Susquehanna River near Lock Haven, Pennsylvania (Figure 1-1). The present report is an effort to merge the records of site occupation and preservation within the broader context of the Susquehanna's floodplain history over the past 10,000-12,000 years. Interpretations are the product of a carefully designed program of field work and laboratory analysis. The program's objectives were to supplement and integrate the results of nearly 15 years of previous research at the site and its immediate vicinity. The geoarcheological approach of this study reflects the convictions of the contractor, that the rich but varied archeological occupations registered in the flooplain of Memorial Park are best understood through systematic reconstruction of the Holocene landscape history of this portion of the Susquehanna drainage basin.

Background to the Study

The impetus for this research derives from the results of phased investigations performed at the site since 1979. Three separate projects identified complex interdigitations of prehistoric and geological deposits collectively spanning 8,000 years. Every major prehistoric period from Middle Archaic to Late Woodland/Clemson Island is represented in sealed, stratigraphic context. Independent interpretations reached by all these studies converged around variability in the floodplain history of the Susquehanna to explain uneven vertical and lateral distributions of cultural deposits across the presently level, first terrace (T-1) surface. All excavators identified the dominant Clemson Island/Late Woodland component that capped the landform in nearly all loci investigated. During Phase II, evidence for extensive earlier Woodland occupations was identified, as well as prominent indicators for deeper Late Archaic horizons (Neuman 1989). During Phase III more comprehensive subsurface testing isolated 13 discrete prehistoric components, the oldest of which was Middle Archaic (Hart 1993).

Figure 1-1



Location of Memorial Park Archeological Site, 36CN164

The Phase III work produced a broad sampling of radiocarbon dates that documented the earliest sustained cultural activities on site at approximately 7,000 years ago (Hart 1993: Table 47). Both the Phase II and Phase III studies isolated a series of five to seven soils to infer complex geomorphic cycles initiated by floodplain aggradation, followed by intervals of stability and soil formation, and terminated by erosion. The Phase II interpretations generally characterized more stable cycles, implicating subdued floodplain activity and the dominance of extensive soil horizons uniformly blanketing the terrace (Neuman 1989). The more comprehensive Phase III geomorphic model drew on the extensive series of Middle Holocene and later dates to chart a more dynamic floodplain environment (Hart 1993: Chapter VI). Changes in terrace morphology involved migration of the channel and abandonment of portions of the floodplain. Such changes were time transgressive and were characterized by the passage from lateral accretion to overbank deposition. By later Holocene times, the near level surfaces reflected sustained overbanking and the permanence of Susquehanna stream flow in its present channel (Hart 1993: Table 11). It was implied, but not demonstrated, that systematic transformations to floodplain topography produced irregular surfaces; these, in turn, were available for occupation at discrete points in time.

While broad stratigraphic relations were outlined in the Phase II and Phase III studies, they were never comprehensively integrated with the archeological sequences *senu stricto.* The uneven distributions of archeological deposits highlight a series of questions bearing on the lateral and vertical variability of floodplain soils and sediments. The key issues remaining may be summarized as follows:

- Isolation of major breaks in floodplain depositional history and topography; it is necessary to isolate buried landforms that preserve prehistoric activity areas;

- Resolution of a soil chronology for the terrace that accommodates pedological observations of previous studies;

* Identification of the base of the Holocene to index the general pattern of environmental change since the end of the Pleistocene;

* Development of a site formation model incorporating regional geoarcheological sequences and paleoclimatic and hydrographic influences.

Scope of Work and Objectives

To address the aforementioned issues, a Scope of Work (SOW) was prepared that stressed incorporation of the results of the previous work as much as possible. Plans for additional fieldwork involved filling in gaps in the deeply buried soil and sediment chronology. Specifically, it was critical to index the rich and deeply stratified archeological deposits recorded by the sixteen (16) excavation blocks dug during Phase III (Hart 1993: Figure 1-4). Towards this end a total of ten (10) deep tests were excavated alongside the former blocks to varying depths. The SOW involved performance of five discrete tasks (COE 1993):

* Mobilization and Trench Location;
* Excavation of Trenches;
* Documentation of Stratigraphy, Sampling, and Demobilization;
* Soil Analysis; and
* Report Production.

Field work began on May 26, 1993, and was concluded on June 12, 1993, (Tasks 1 and 2). Concurrently, complete documentation of soil and sediment stratigraphy was performed, including sampling of trench columns for a variety of geochemical, mechanical, and radiometric tests and identifications to reconstruct the Holocene stratigraphy (Task 3). Samples were subsequently submitted to several laboratories for analysis (Task 4).

Summary objectives of the present study were to:

* Produce a baseline stratigraphy incorporating depositional and soil stratigraphic sequences;

* Obtain provenienced radiocarbon samples to index the site chronology and stratigraphy outlined above;

* Integrate previous geomorphic and archeological data sets within the refined model of site development.

CHAPTER 2: ENVIRONMENTAL BACKGROUND

The Memorial Park archeological site occupies a 5.5-7 m (18-23 ft) high first terrace (T-1) overlooking the south bank of the West Branch of Susquehanna River near Lock Haven (Figure 1-1). The terrace abuts the surface of present floodplain (T-0) that grades gently (< 3°) to the waterline (Plates 2-1 and 2-2). Surface elevations range between 168-169 m (551-555 ft) above mean sea level and the active river channel. The site landform has been mapped as a remnant terrace of the Late Wisconsinan Port Huron Substage terrace but preserves variable thicknesses of Holocene alluvium to depths of 3 m.

The confluence of Bald Eagle Creek with the trunk stream is approximately 1.3 km (0.8 miles) southeast of the downstream end of the site (Figure 2-1). The combined floodplains of the West Branch and Bald Eagle Creek are 1.6 km (1 mile) wide at this location. The major areas investigated are located between Piper Memorial Airport on the south and west, and the West Branch channel on the north and east, near the bifurcation of the stream that forms Great Island (Figure 1-1). Bald Eagle Mountain is located to the south of Bald Eagle Creek and the West Branch, while the northern valley margins are hemmed in by Simcox Mountain and associated uplands (Hart 1993).

Climate and Soils

The Memorial Park Site is located in the upper and central West Branch of the Susquehanna sub-basin of the Susquehanna River Basin. Storm tracks frequently cross the sub-basin from the north, west, and south. Storms from the east are less frequent. Typically, winter storms and fronts originate in central Canada and travel south from Hudson Bay or east from the Rocky Mountains. Cold Canadian air, clear skies and snow cover may cause sub-zero weather. Periodically, warm air from the Gulf of Mexico travels north causing alternate freeze-thaw cycles. The Atlantic Ocean has less effect on the weather, storm and precipitation-patterns. Winter weather is highly variable and extended periods of extreme cold are rare. Summer weather and circulation systems usually originate from the southwest. Summer storms are accompanied by heavy rains or hot, humid weather with temperatures peaking during July. During July and August, rates of evapotranspiration exceed precipitation, and soil and water deficits occur.

Mean annual precipitation for the study area is approximately 40 inches (15.75 cm). Average annual temperatures in the study area range from 45°F to 50°F. Temperature extremes range from as high as 105°F in August to as low as -31°F in January. Because of the variable topography and relief, the mean annual freeze-free period varies from 130 to 165 days.

The main soil association mapped for the project area is the Ashton Silt Loam (Steputis et al., 1966) (Figure 2-2). It has been mapped across the T-1 landform on the south bank of West Branch and extends onto Great Island and north bank/terrace landscapes to the east. The steeper terrain across the West Branch to the north and west is capped by a series of sandy and silty loams of more localized distribution. In general, Ashton silt loams are considered deep and well drained across terrace expanses (Steputis et al., 1966). Locally, drainage has been somewhat impeded by both the depth of subsurface silt loams (with low porosity) and the frequency of flooding.

Hydrography and Hydrology

The headwaters of the West Branch of the Susquehanna River are located in central Pennsylvania in Cambria County near Ebensburg. The stream flows north for approximately 48 km (30 miles). It then follows a northeast course for 80 km (130 miles) and then south for another 50 km (80 miles) across the Appalachian Plateau to the Allegheny Front, just west of Lock Haven. At this point, the river enters a somewhat broad, asymmetric fertile valley and flows westward for ca. 64 km (40 miles). Finally, it drains southward to its confluence with the main stem of the Susquehanna at Sunbury. The West Branch has an average channel slope or gradient of 3.3 m/km (10 ft/mile) above the Sinnemahoning Creek, and about .8 m/km (2.5 feet/mi.) below that point, to its confluence at Sunbury. The drainage area of the West Branch above the Jay Street Bridge at Lock Haven is 5,339.2 square

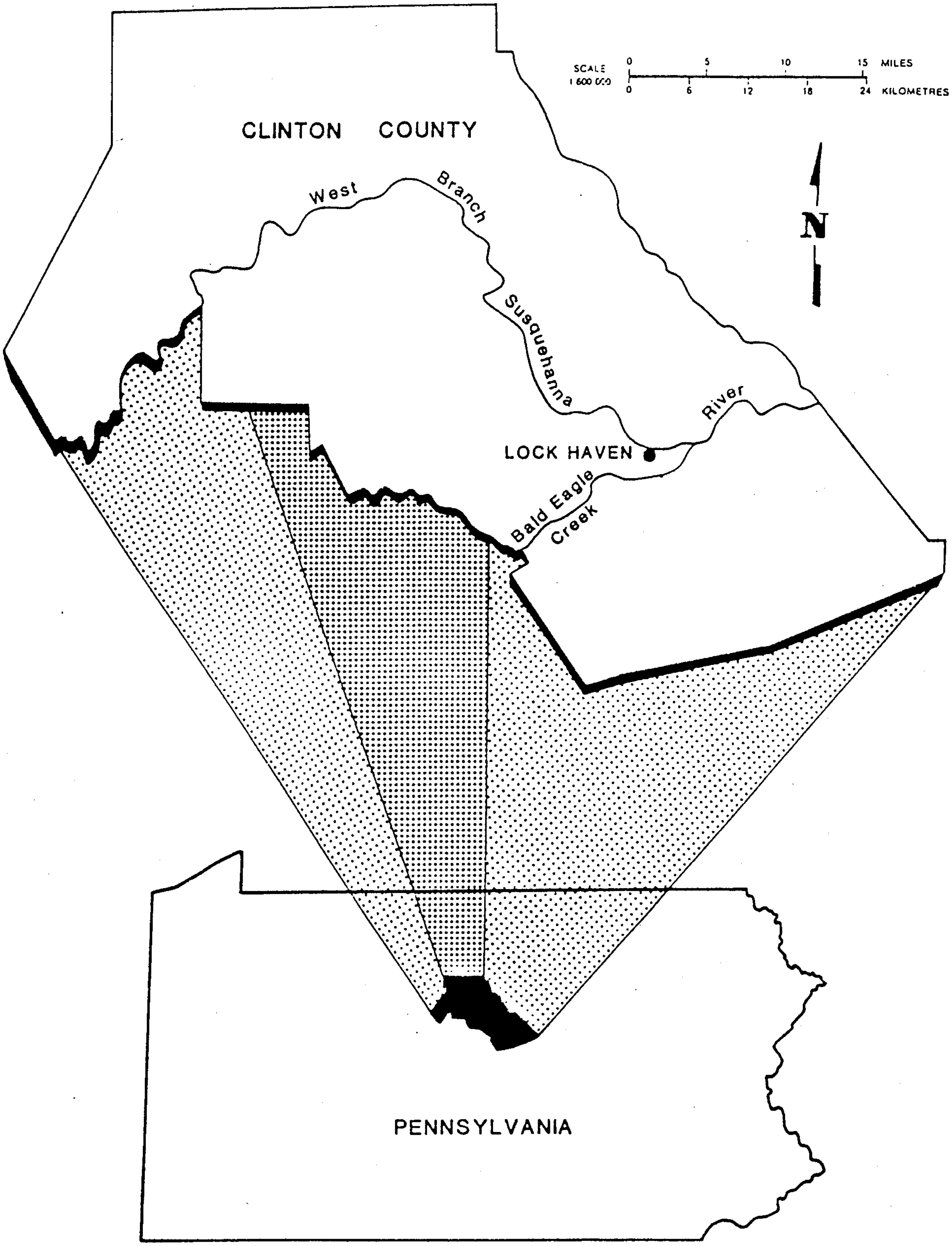
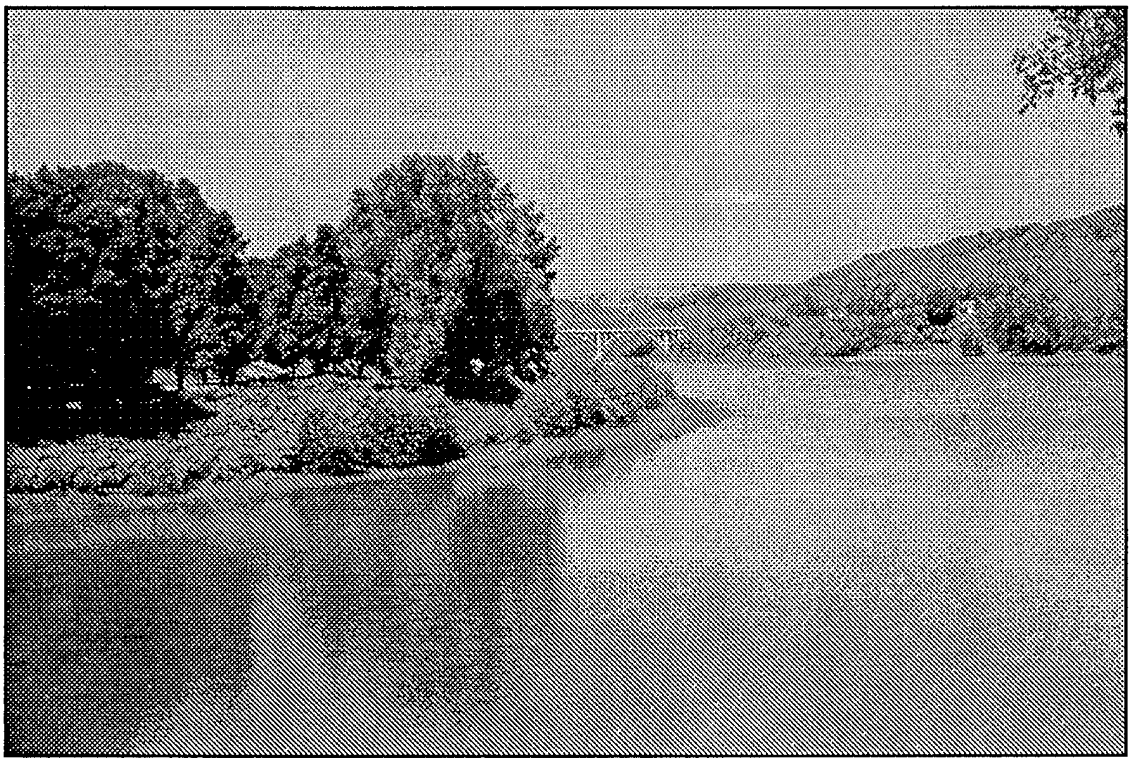


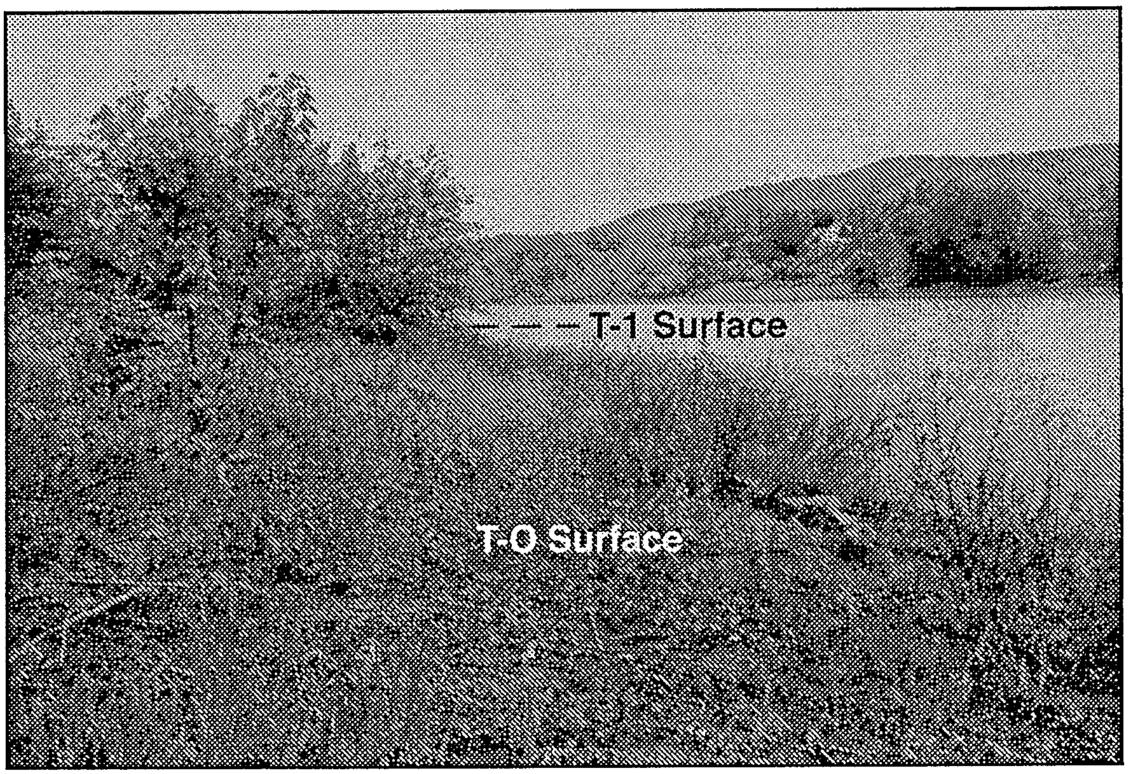
Figure 2-1. Regional Map of Memorial Park site, 36 CN 164

Plate 2-1



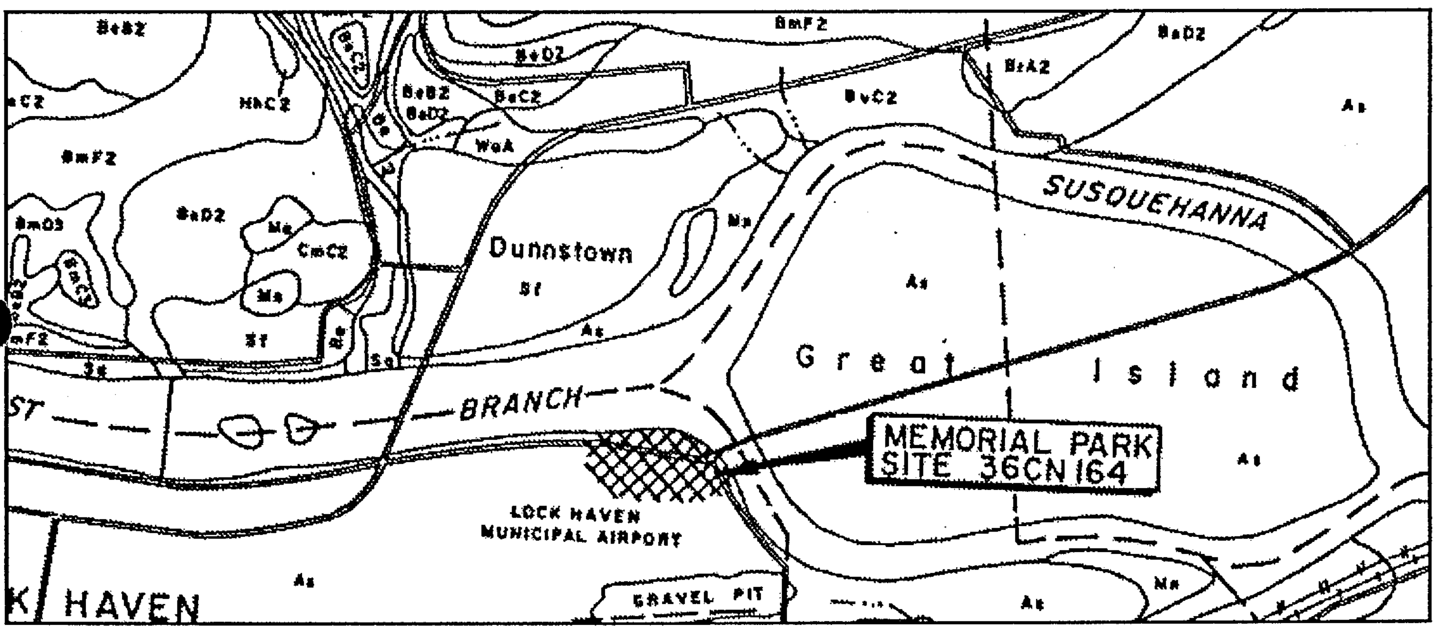
The T-1 landform, Memorial Park site, 36CN164. View to west.

Plate 2-2



View of T-O Surface at Memorial Park facing west. T-1 is offset by trees in upper portion of photo.

Figure 2-2



Soil association map showing extent of Ashton silt loom (symbol "As") km (3,337 sq. miles).

The floodplain near the site is approximately 1.6 km (1 mile) wide. The west Branch of the Susquehanna River emerges from the Appalachian Plateau as a transverse/superposed stream meandering through a floodplain approximately 0.9 km wide. Bald Eagle Creek drains a subsequent valley along the base of Bald Eagle Mountain. Its floodplain width varies from 0.5 to 1.8 km, reaching maximum breadth near Lock Haven. At the Bald Eagle Creek confluence, the West Branch turns at a right angle eastward following the subsequent valley to Montoursville.

The West Branch of the Appalachian Plateau is a consequent stream that has developed or superposed its channel across rocks deformed during the Appalachian orogeny. Accordingly, while West Branch channel flow cuts the rock structure, it contains long reaches which follow in a subsequent fashion the east-northeast structural grain. Most of the major tributaries to the West Branch are subsequent streams which course along the strike of weak Silurian and Devonian limestones and shales. Most of the smaller external and internal drainage links to the West Branch are best classified as consequent streams.

Bald Eagle is an underfit stream; it appears to be too small for the size of the valley it occupies (Hart 1993; Thornbury 1969). Underfit streams commonly result from drainage changes produced by stream diversion. The West Branch is a larger stream that emanates from the Allegheny Front of the Appalachian Plateau and then turns and occupies the subsequent valley all the way to Altoona or beyond. Earlier, a smaller stream draining the present West Branch valley north of Lock Haven functioned as the trunk stream through stream piracy and expansion of its drainage net (Hart 1993:23).

According to Hart (1993) stream and depostional regimes at the confluence of the West Branch and Bald Eagle Creek may underscore their linked Late Quaternary hydrographics. Near Lock Haven the two streams run parallel to each other for aproximately three kilometers. At their juncture, the West Branch diverges into north and south arteries. The land between the channels is known as Great Island.

Either of the arteries may comprise a former, smaller flow line; diversion occurred when the original channel was choked with glacio-fluvial sediments. Bucek (1975) noted that minor tributaries to the West Branch contribute abundant sediments into the main valley and promote deflection of the West Branch southward to the toe of Bald Eagle Mountain. Previous geological investigations at Memorial Park (Vento 1987) had identified a buried channel to the south of the Memorial Park Site at the Piper Memorial Airport. Presently, it is not known if this is a buried remnant channel of Bald Eagle Creek, the West Branch or the ancestral stream noted above (see Figure 2-3).

For the past century there is excellent documentation for the flow patterns of the West Branch. Continuous streamflow records of river stages and discharges have been maintained since 1928. These records demonstrate that even though most of the annual precipitation falls between March and May, minimal stream flows are registered from June through October; September and October are the lowest flow months. During these low flow periods the West Branch and Bald Eagle Creek are primarily supplied by base flow (groundwater recharge).

Two principal controls regulate flooding at the Memorial Park Site: 1) peak discharge (flood stage) on the West Branch of the Susquehanna River, and 2) peak flows on Bald Eagle Creek. In most cases, flooding along Bald Eagle Creek is a function of downstream base-level control by the West Branch. As a result of backflooding from the West Branch, inundation along Bald Eagle Creek is usually coincident with floods on the West Branch.

Records show that flows on Bald Eagle Creek can and have in the past caused minimal increases in flood elevations downstream from the confluence with the West Branch. Table 2-1 lists estimated flood crest elevations above bankfull stage (21 ft) from 1847-1979 at the National Weather Service gage at the Jay Street Bridge in Lock Haven. Figure 2-4 is the flood recurrence graph which depicts the flood recurrence estimates for the West Branch just downstream from the Jay Street Bridge. These data show that the likelihood of bankfull discharge above mean site elevations (555-557 ft; 169-170 m) is 35-50%. In large measure such a high flood

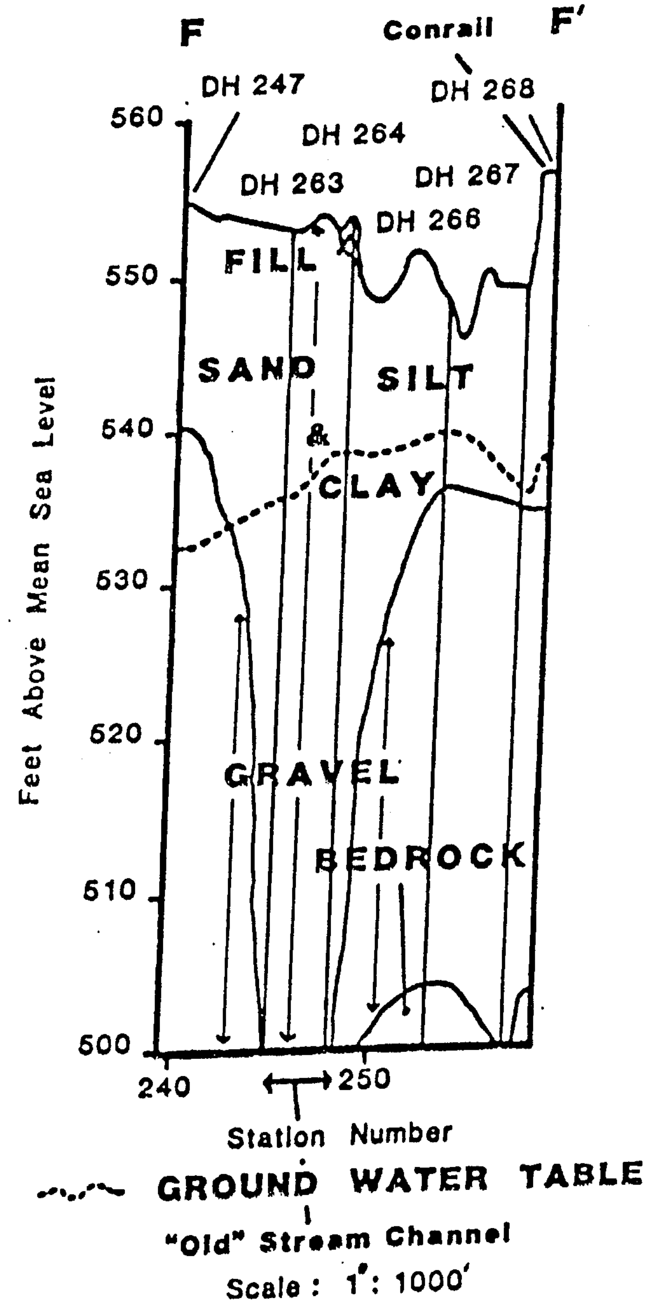


Figure 2-3. Relic and West Branch stream channel incised into bedrock, Memorial Park Site (from Vento 1987: Figure 7). Data accumulated from coring logs.

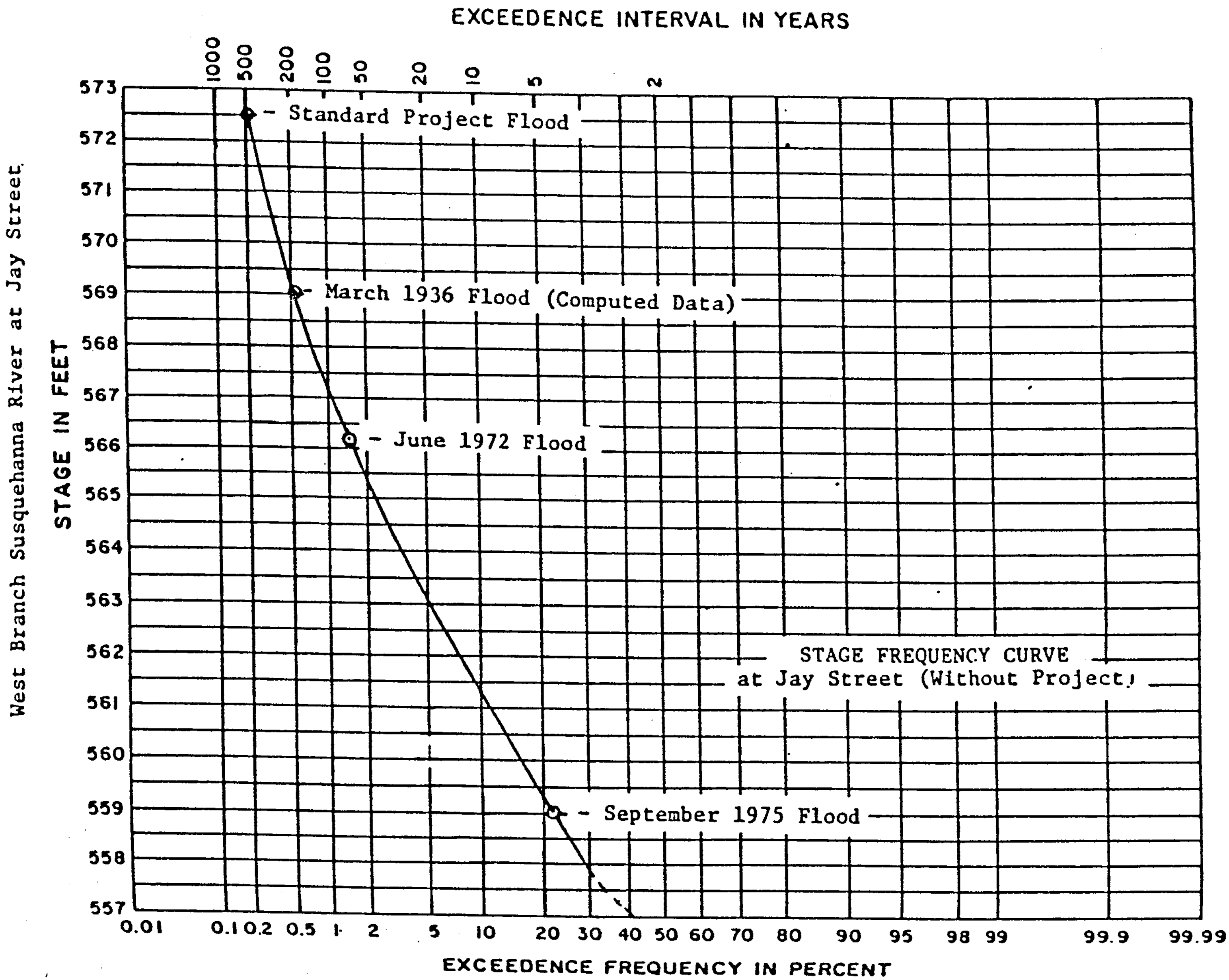


Figure 2-4. Flood recurrence graph for the West Branch of the Susquehanna River at the Jay Street Bridge (taken from thePhase I General Design Memorandum, Army Corps of Engineers, Baltimore District: 1980).

Table 2-1: **Known stages and discharges above flood stage (21 ft) at the National Weather Service gage at the Jay Street Bridge for the period 1847-1979 (after Phase I General Design Memorandum, Army Corps of Engineers, Baltimore District: 1980).**

West Branch Susquehanna River, Lock Haven Pennsylvania, Estimated Flood Crest Elevations Above Bankfull Stage - 1847-1979.

Known stages and discharges above flood stage (21 feet) at the National Weather Service gage at the Jay Street Bridge in Lock Haven are tabulated below. Drainage area = 3,337 square miles; Gage datum = 535.18 feet, m.s.l.

Date of Crest	Stage (ft)	Estimated Elevation	Discharges (cfs)
1847[1]	25.3	560.5	[2]
1865[1]	24.7	559.9	[2]
Feb. 7, 1878	22.0	557.2	98,000
June 1, 1889	29.8	565.0	192,000
May 1894	26.4	561.6	141,000
Mar. 1, 1902	23.7	558.9	113,000
Mar. 4, 1904	24.2	559.4	117,000
Mar. 14, 1907	24.5	559.7	120,000
Feb. 21, 1918	26.8	562.0	146,000
Mar. 4, 1923	25.1	560.3	126,000
Mar. 18, 1936	32.3	567.5	238,000
Apr. 1, 1940	21.7	556.9	95,000
Dec. 31, 1942	23.2	558.4	108,000
May 28, 1946	26.9	562.1	147,000
Nov. 26, 1950	27.6	562.8	157,000
Jan. 26, 1961	21.1	556.3	90,000[3]
Mar. 10, 1964	26.1	561.3	138,000[4]
June 23, 1972	31.3	566.5	190,000[5]
Sept. 26, 1975	22.9	558.1	91,500[5]

[1] From "Lock Haven Express," March 17, 1964.

[2] Not determined.

[3] Upstream control by George B. Stevenson Reservoir.

[4] Upstream control by Stevenson and Alvin R. Bush Reservoir.

[5] Upstream control by Stevenson, Bush, and Curwensville Reservoirs.

recurrence probability accounts for the deep record of Holocene alluviation and site preservation.

Site Setting and Physiography

Memorial Park is at the junction of two major physiographic provinces: the Appalachian Plateau (both the glaciated and unglaciated sections) and the Ridge and Valley. The Allegheny Front is the division between the gently folded Appalachian Plateaus to the north and west and the more prominently folded Ridge and Valley to the south and east (Figure 2-5).

The Appalachian Plateaus Province contains maturely dissected upland surfaces with altitudes higher than those of adjacent provinces; lithologies are typically younger (Thornbury 1965). The rocks are dominantly clastic with some coals; marine limestones feature more limited distributions and reflect episodes of marine transgression on a once lower delta plain. Unlike the Ridge and Valley, lithologies of the Appalachian Plateaus have not been subjected to intense compressional and tensional deformation. From west to east the magnitude and extent of deformation increases. Dissection across the plateau surfaces dates to the Cenozic Era. Valley systems are characterized by dendritic drainage nets.

Landscapes spanning the Glaciated Appalachian Plateaus of the Applachian Plateaus province were modified by Pleistocene glaciation, particularly during early to late Wisconsinan times. Terrain transformations were brought about by depositions of poorly sorted glacial tills, periglacial phenomena, and intensified dissection promoted by glacial meltwaters and subsequent isostatic uplift following deglaciation.

The Allegheny Mountains Section (or Allegheny Front) is a subdivision of, and a northeastern margin to, the Appalachian Plateaus (Thornbury 1965) (Figure 2-5). The late Cenozoic fluvial incision of the Allegheny Mountains is so advanced that extensive plateau surfaces have been largely worn away. Across the uplands, open folds are expressed as linear ridges, and the topography was largely unmodified by

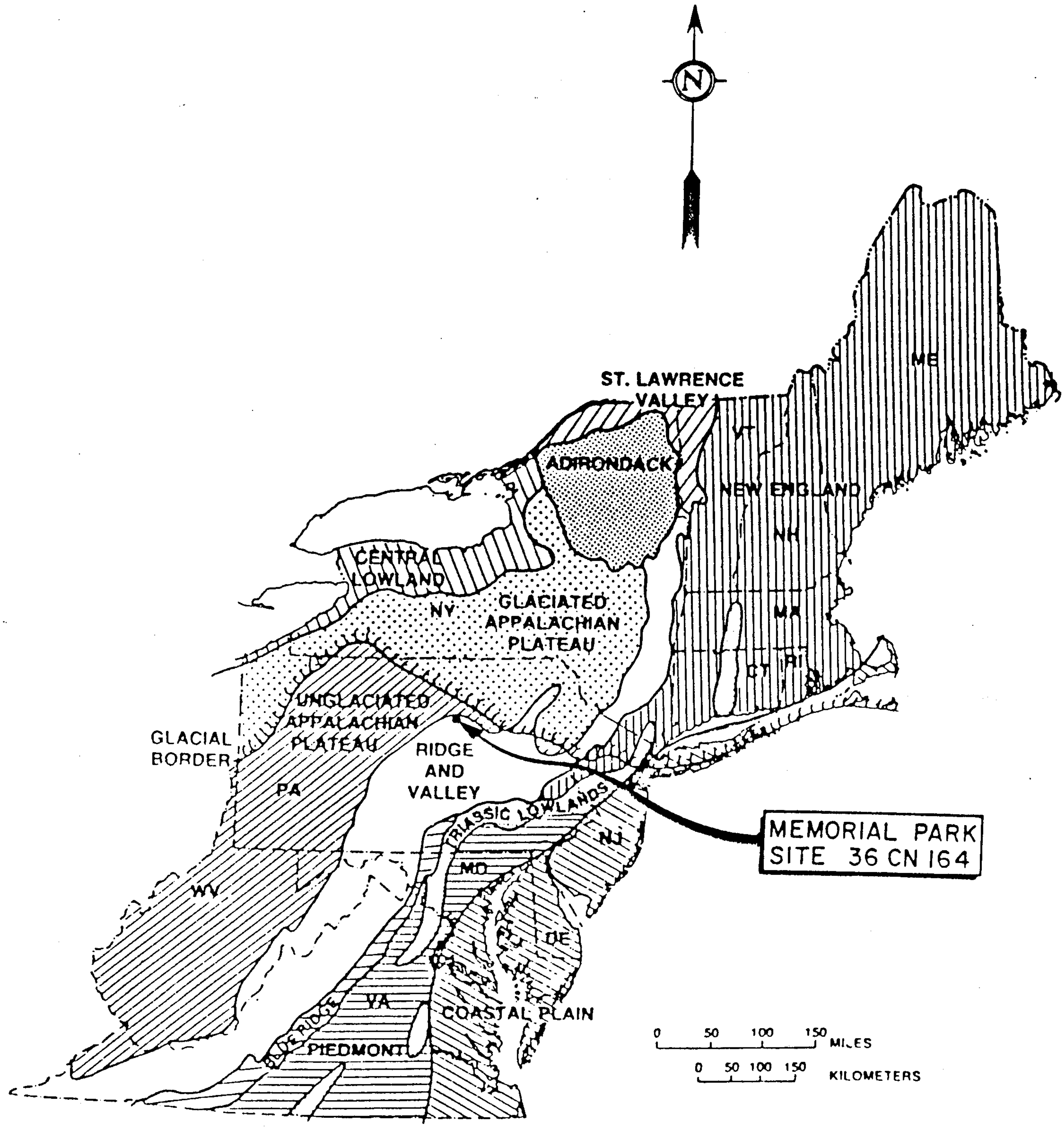


Figure 2-5. Physiographic Location of Memorial Park Site (from E.J. Ciolkosz et al., 1989 as modified by GAI 1993)

glaciation. Drainage patterns evolved into trellis-like systems near the Allegheny Front and reflect the structural and lithologic controls of the bedrock systems.

The Ridge and Valley province is an assemblage of valleys or low valley lowlands surmounted by narrow, linear, often even-topped ridges (Thornbury 1965). The many striking geomorphic features of the Ridge and Valley include: prominent sets of parallel ridges and valleys oriented chiefly NE-SW; an influence of alternating strong and weak strata upon topographic forms; and isolated trunk drainages with subsequent streams that initiated trellis drainage nets. Numerous ridges display sufficient accordance of summit level to implicate a former erosion surface. Hundreds of water gaps have subsequently emerged through hard rock ridges (Thornbury 1965; Hart 1993; Vento and Rollins 1989).

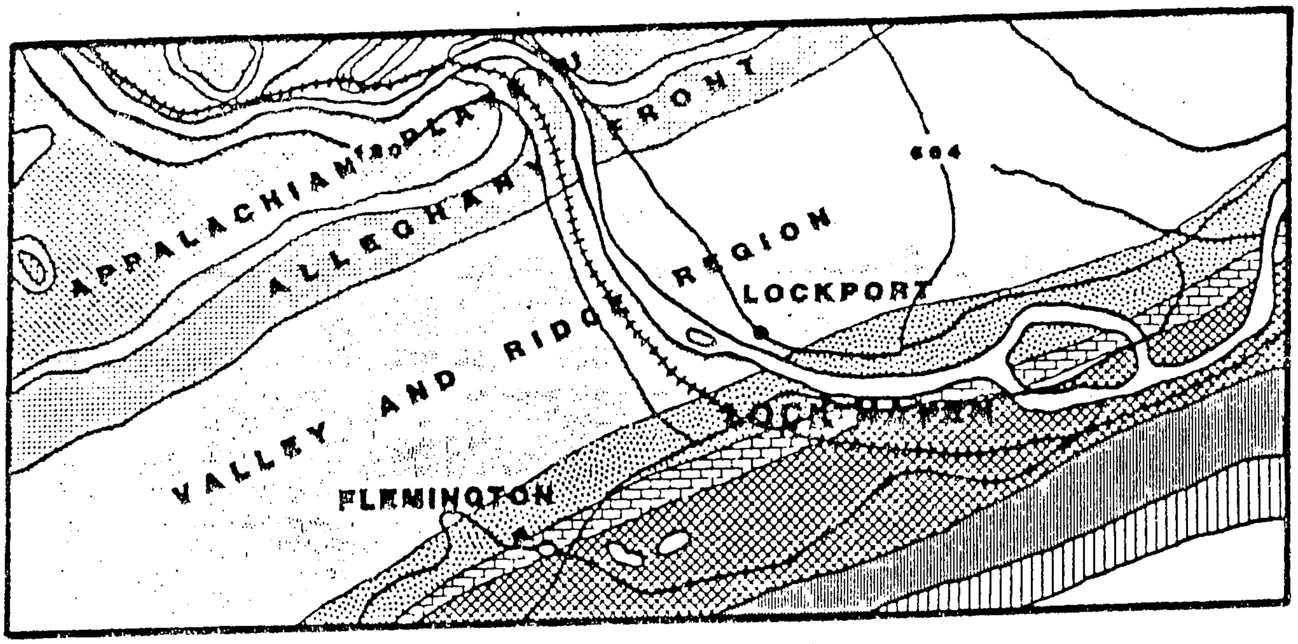
Present Ridge and Valley topography is a result of truncation of folds during several Cenozoic erosion cycles (Thornbury 1965). Differential erosion of weak and strong beds has accentuated structure, presently expressed by anticlinal, synclinal, and homoclinal ridges and valleys. Between Bald Eagle Mountain and the Allegheny Front a narrow subsequent valley developed on Devonian limestone. This valley formed the drainage trough of the northeastward-flowing Bald Eagle Creek, the principal regional tributary, which enters the Susquehanna River Valley just east of the City of Lock Haven.

Bedrock Geology and Stratigraphy

To the north and south of the Memorial Park Site, the steep terrain hemming in the floodplain and terrace systems was fashioned by a series of Late Cenozoic orographic events. These are registered by local bedrock outcrops. A comprehensive summary of the bedrock geology has been presented in previous accounts (Hart 1993; Vento et al., 1988). The following synopsis abstracts only those lithological relations bearing on the evolution of the Late Quaternary landscapes (Figure 2-6).

South of the Memorial Park Site, below Bald Eagle Creek (Figure 1-1), are limestone and shale outcrops of the Silurian Tonoloway, Wills Creek, and Bloomsburg formations (Taylor 1977). The only extensive exposure near the study area is the red shale of the Bloomburg Formation. It is expressed as a reddish paleosol along the road at the base of Bald Eagle Mountain. Basal lithologies consist of gray to greenish gray shale with interbedded argillaceous, fossiliferous gray limestone beds and lenses on Bald Eagle Mountain. This unit is covered by transported regolith (Colluvium) from the Tuscarora Formation. Rock streams or rock fields are typically associated with the Tuscarora Formation and emerged in response to periglacial climatic conditions. This formation is characterized by light gray to yellowish gray, fine to medium-grained quartzose and sandstone. The Tuscarora weathers to large talus blocks that have exfoliated along the northern flank of the mountain. Extensive boulder fields covering slopes of regional peaks are believed to be periglacial in origin (Hart 1993; Ciolkosz et al., 1986; Denny 1951). South of the Tuscarora, at the crest of Bald Eagle Mountain, is the reddish, very fine grained sandstone of the Upper Ordovician Juniata Formation (Hart 1993).

North of Memorial Park and directly across the West Branch, bedrock outcrops are only differentially exposed (Figure 2-6). Field relations suggest that these and related regolith surfaces have been eroded and/or buried by alluvium (Hart 1993). Protruding younger shales and limestones occur as a series of stepped bedrock benches or straths. The lowermost lithology is the Tully Limestone Member of the Middle Devonian Mahantango Formation. This limestone is gray, micrograined, and interbedded with thin shale beds. Some of the thin shale beds grade laterally into the Shale member of the Mahantango. Above the Tully Member, further to the north, is the Burket Black Shale Member of the Harrel Formation. The Harrel Formation is the basal unit in the Susquehanna Group of the Upper Devonian. The Burket is a black to grayish black, very fissile shale with limestone nodules. Above the Burket is the Upper Shale Member of the Harrel Formation. This shale is grayish and contains thin to thick beds of black shale, siltstone, and sandstone (Ciolkosz et al., 1986; Vento 1987; Vento et al., 1988; Hart 1993). From the vicinity of Dunnstown north to the Allegheny Front the units become wider and form low rolling hills (Kohler 1986). These are stratigraphically above the Harrel Formation.



LEGEND

- Railroad
- Pp Pottsville Group
- Mmc Mauch Chunk Formation
- Mp Pocono Group
- Doo Oswayo Formation
- Dck Catskill Formation
- Dm Marine Beds
- Dho Mahantango, Marcellus, and Onondaga Formations
- 664 Major Routes
- Doh Oriskany and Helderberg Formations
- Skm Keyser, Tonoloway, Wills Creek, Bloomsburg, and McKenzie Formations
- Sc Clinton Group
- St Tuscarora Group
- Oj Juniata Formation

Figure 2-6. Surficial Geology of the Memorial Park Study Area (from GAI 1993).

Quaternary Geomorphology and Chronology

The Quaternary System is represented by a variety of deposits in the vicinity of the study area (Bucek 1975). Floodplain areas are generically mapped as Quaternary Alluvium by Taylor (1977: Figure 8). As noted earlier, the border between the Unglaciated and Glaciated Appalachian Plateau border is near the site, but the Wisconsinan glacial topography is not sharply offset across the valley-edge landscapes (Thornbury 1965). Early accounts are ambiguous in classifying the Memorial Park area as "glacial terrain" (Leverett 1934). Most recent maps place the location 20 km south of the Wisconsinan Drift border (Bucek 1975; Crowl and Sevon 1980; Denny 1956). However, proglacial deposits, pre-Wisconsinan deposits, and periglacial phenomena extend throughout Clinton County and south into the Ridge and Valley Province (Bucek 1975; Ciolkosz et al., 1986; Denny 1951; Marsh 1987; Steputis et al., 1966).

It is significant that surface deposits covering landscapes immediately north and east of the West Branch, and at all elevations, contain till-like pockets of gravel and stones in sand and clay rich matrices (Steputis et al., 1966). The closest glacial till soils formally mapped near the site are the Allenwood soils near Woolrich 10 km (6.25 miles) to the northeast. Soils mapped immediately north of the site, on the shale benches, are of the Berks association and formed in shale bedrock. Locally colluviated residual soils are difficult to distinguish from redeposited old tills (Crowl and Sevon 1980). Regionally, the glacial drift of Lycoming County consists of unsorted till, outwash, and stratified drift (Kohler 1986). There are also large areas of stony and bouldery colluvium, and some boulder fields.

According to Denny (1956), pre-Wisconsinan deposits are mapped up-valley of all major streams in the northern Appalachian Plateau of Pennsylvania. Landform-sediment complexes include kame terraces, valley train terraces, and strongly weathered drift, colluvium, alluvium, or residuum. Weathered sediments have been collectively referred to as the pre-Wisconsinan paleosol (Denny 1956; Denny and Lyford 1963), assumed to be Sangamon in age (Snyder and Bryant 1992; Waltman et al., 1990). Waltman et al., (1990) have named this the Pine Creek

Paleosol. Pre-Wisconsinan terraces and Wisconsinan terraces are difficult to differentiate as are colluvial deposits of similar age (Denny 1956; Leverett 1934). The strongly weathered Sangamon age paleosol has been used as a benchmark to distinguish pre-Wisconsinan from Wisconsinan aged materials (Denny 1956; Snyder and Bryant 1992; Waltman et al., 1990; Hart 1993). One terrace, approximately 20 meters above the West Branch near Shintown had a reddish paleosol (Sangamon) covered with 50 cm of yellowish brown loam (Denny 1956). Kettle Creek and Pine Creek both have alluvial fans and colluvial benches that do not contain the paleosol and thus are assumed to be late Wisconsinan in age. Pre-Wisconsinan colluvial and fluvial deposits have been mapped near Lock Haven based on the signature of a well-developed paleosol (Bucek 1975; Hart 1993).

Glacial lakes also dominated the pre-Wisconsinan regional landscapes. Lesley I and Lesley II lakes formed when the Illinoian Muncy ice sheet dammed the West Branch at Muncy (Bucek 1975). During peak lake level stands this lake was at least 64 km long and backed up Bald Eagle Creek valley to Milesburg. However, formal lake features all occur at elevations greater than 182 m (597 ft), fully 5 m (16 ft) above Memorial Park elevations. No lacustrine features or lake deposits were identified in the immediate vicinity of the site.

As with older deposits, it is often difficult to distinguish between late Wisconsinan and Holocene gravelly and cobbly alluvial fans at the outlets of tributary streams (Denny 1956). The gravelly and cobbly fans at McElhattan, Rauchtown, and Woolrich were probably laid down during Wisconsinan time by the large volumes of water that emanated from mountain streams (Steputis et al., 1966). The possibility of a Wisconsinan loessal input has been suggested to explain the silty nature of the upper horizons (Denny 1956; Denny and Lyford 1963; Marchand 1978; Snyder and Bryant 1992; Waltman et al., 1990). The loess overlies a variety of older Pleistocene deposits.

South of the glacial border the Wisconsinan is largely represented by periglacial deposits and features (Ciolkosz et al., 1986; Denny 1951, 1956). One of the more striking examples is the large block field or rock stream deposit on Bald Eagle

Mountain, visible from the Memorial Park. Dominant periglacial features include patterned ground, rock and soil wedges, assorted colluvial deposits, blockfields and streams, cryoplantation surfaces, and niviation hollows (Clark and Ciolkosz, 1988). The distinct east-west flowing streams in the region may be a result of gelifluction lobes pushing the channel to the north, the scouring/erosive effects of niviation hollows on the north-facing slopes, and more frequent freeze-thaw cycles promoting active soil creep. In the vicinity of the study area the majority of periglacial features are believed to be early Wisconsinan (Denny 1951, 1956), although Waltman et al., (1990) have classified the periglacial Slate Run Colluvium as Woodfordian (late Wisconsinan).

The late Wisconsinan is also represented by fluvial landforms, chiefly fans and terraces. Crowl and Sevon (1980) have assessed an Olean (Woodfordian) age to the outwash terrace bordering the Susquehanna River near Nescopeck. Alluvial terraces in Lycoming County consist of sheet-like deposits and lengthy gravel bars (Kohler 1986). Recent alluvial fills (i.e., Holocene) occur in most of the small tributaries and main streams.

Terrace Stratigraphy, Morphology and Sedimentation: The Last 12,000 Years

Vento and Rollins (1989) have described four distinct late Wisconsinan age terraces within the Susquehanna drainage basin. Their model draws on Marchand et al. (1978) who earlier identified as many as six or seven Woodfordian outwash terraces. The Vento and Rollins (1989) model (see also Vento et al., 1992) considers the oldest and highest of the four terraces to be the Olean described above. In decreasing age and elevation the remaining terraces are the Binghamton/Kent, the Valley Heads, and the Port Huron.

The Port Huron (4 m/13 ft) and the Valley Heads (7 m/23 ft) have been associated with artifact bearing strata, apparently laid down over eroded Woodfordian surfaces (Vento and Rollins 1989:8). The Memorial Park site occurs on the Port Huron terrace 6 to 7 m above the active Holocene channel (Vento and Rollins, 1989).

The terrace surface does not intersect any higher or older terrace risers or valley walls. Accordingly, all sediment contributions to the landscape are derived from floodwaters.

Surfaces of the landform are the highest that are typically breached by Holocene inundations of the Susquehanna. For this reason, periodic floods over the course of the Holocene have differentially sealed and eroded prehistoric deposits across Port Huron surfaces the length of the Susquehanna. The historic stream flow records suggest that under natural flow conditions (i.e., those unaffected by existing reservoirs, dams, and levees), the Port Huron terrace is inundated once every seven years. Most of these overbanking events have occurred during late winter or early spring in response to more effective precipitation, snowmelt, and lowered evapotranspiration rates. The present study indicates that periodicity of overbanking may have increased over the past 50 years as a result of several exceptionally torrential floods (i.e., 1936, 1972; see Figure 2-4); these have left measurable, freshly bedded alluvium across the T-1.

Buried soils on bank edge and low terrace contexts within the basin have been attributed to intervals of floodplain stability punctuated by intervals of overbanking and channel avulsion. The periodicity of channel stability and dynamism, in the form of active vertical and lateral accretion and channel migration, reflect on changing Holocene climatic cycles (Vento and Rollins 1989). Most recent data (Vento et al., 1992) suggest that the Susquehanna featured a braided channel regimen prior to 11,000 B.P. The broad terraces extending downstream to Conawingo Falls register a lengthy interval of braiding during the Pleistocene. The present work is demonstrating that active meandering at Lock Haven may have been initiated at around 11,000 B.P. and since then the floodplain has undergone cycles of channel avulsion, migration, and vertical accretion capped by stability and soil formation. In particular, these investigations point to long term channel migration to the northeast during the Early and Middle Holocene. Above the channel and outwash sediments a complex fluvial stratigraphy and soil chronology interdigitates with a series of archaeological deposits. The history of the Holocene floodplain and its occupational succession are the subject of the present investigations.

CHAPTER 3: PREVIOUS INVESTIGATION

Archeological study of the Memorial Park Site was initiated by Hay et al., (1979; see also Hay and Stevenson 1982), who excavated two tests pits and recovered definite Clemson Island (Late Woodland) and probable Archaic materials in subsurface context. This work delimited the site boundaries and resulted in National Register nomination.

Systematic archaeological coverage of the site landform was undertaken during Phase II and is detailed in Neuman (1989). A comprehensive program of augur testing, test unit excavation and deep testing was implemented. Archeological deposits were recovered in fifteen (15) 1 x 2 m excavation units and six (6) backhoe trenches. Excavations demonstrated the presence of stratified Late Woodland, Middle Woodland, Transitional/Terminal Archaic, and Late Archaic horizons to depths of 3 m. A Data Recovery Plan was proposed to isolate the extent of the sizable Clemson Island component, to probe the depth and extent of the Late Archaic occupations and to test for the presence of even earlier components.

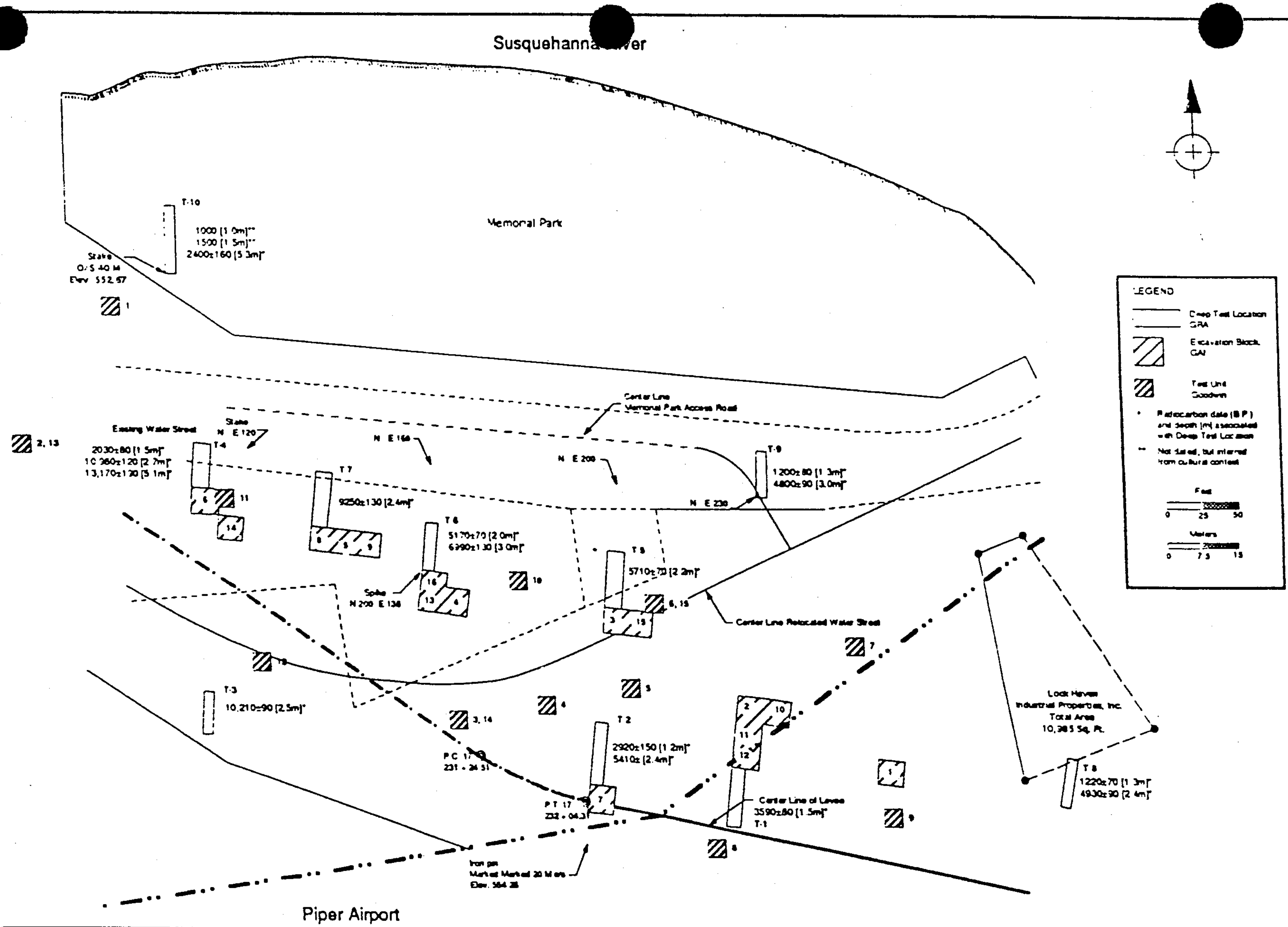
Phase III studies instituted the Data Recovery Plan and are reported in Hart (1993). Strategies consisted of wide area stripping to expose Late Woodland/Clemson Island features (50 x 200 m); excavation of twenty-seven 1x2 m units and feature removal; hand excavation of seven 5x5 m blocks; and deep testing in 2x2 m blocks supplemented by expanded excavations in the deeper deposits. The total number of units hand excavated and trenched in the deep blocks has not been identified to date (see Hart 1993: 80-85, Figure 13 missing). The Phase III excavations recovered 253 features, four Late Woodland components, and seven additional Archaic components extending the sequence to the Middle Archaic, ca. 8,000 B.P., (Hart 1993: 129). Placements of all Phase II and III excavation blocks along with the GRA Deep Trenches are presented in Figure 3-1 showing the effective coverage of site excavations for all major archeological projects undertaken to date.

Geoarcheological observations were made over the course of both Phase II and III excavations. The perspectives adopted for each phase varied, first, in accordance with the changing Scope requirements for the two phases and, second, as a function of the analytical orientations of the earth scientists responsible for interpretations. Both studies, however, called attention to the differential patterns of site sedimentation and soil formation across what is now a visually homogeneous landscape. Significantly, in each study the complexities of site stratigraphy were identified in earlier stages of project work.

Phase II

At the Phase II level, Neuman (1989: 43-46, Figure 23) developed a soil stratigraphy that isolated six discrete pedogenic sequences spanning about 5500 years. Almost everywhere across the site the top of the sequences is capped by the contemporary decomposing humic mat, marking the Historic soil ("Soil 1"). It is underlain by discontinuous flood deposits ("C1 and C2 sands"), effectively forming an "A-C" profile. The flood-deposits are discrete, single event depositions attributed to the massive inundations of the Susquehanna during 1940 and 1942 (Neuman 1989: Figure 24). A buried plow zone ("Apb horizon") pre-dates the mid-twentieth century floods and forms the top of the first subsurface solum. It occasionally truncates the underlying "Ab horizon", the uppermost intact prehistoric soil containing Late Woodland (i.e., Clemson Island) components ("Soil 2"). As discussed elsewhere, the boundary between the Apb and the intact Ab is sufficiently diffuse and gradational as to produce problems in identification and differentiation. A Cambic ("Bw") horizon underlies both horizons and the entire solum is of Woodland age. Soil 3 is immediately underneath and spans the Woodland/Transitional Archaic. Soils 3, 4, 5, and 6 were all considered to be Late Archaic.

The disposition of the soils is projected across the entire site landscape along a series of three transects (Neuman 1989: Figure 24). Soil sequences appear to span the T-1 terrace almost uniformly, with only very minor variations in solum accumulation. The weathering pattern is cyclic and remarkably continuous, with five superposed "A-Bw" sola underlying the culturally modified Historic Soil ("Soil 1"). These had been tentatively identified as Inceptisols (Neuman 1989: 40) with organic ("Ab")



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DRAWING TITLE

Fig. 3-1 Location of all excavation units and deep trenches with radiocarbon dates.

PROJECT	DRAWN BY	SCALE
Lock Haven, PA	drb	1" = 100'
	DATE 10/19/93	REVISION 10/19/93

horizons sealing in Cambic ("Bw") horizons with average thicknesses of 20-25 cm; only "Soil 4" (Late Archaic) diverged from this pattern, with a more strongly weathered basal sub-horizon 70 cm thick. The soil chronology is based on the cultural stratigraphy; breaks are designated on the seriation of assemblages or on the distribution of diagnostic artifacts. Dates are extrapolated from chronostratigraphic relations developed by Vento et al. (1988) over the course of deep testing of multicomponent sites along the Susquehanna River.

Neuman's (1989) provisional model for landscape change at Memorial Park is derived almost exclusively on a soil stratigraphy synthesized from visual inspections at the block units and deep tests at the site. No depositional-erosional cycles for floodplain or terrace evolution are postulated. Since no radiocarbon dates were taken from any of the excavation units or deep tests, only a projected chronology was developed by integrating diagnostic archeological assemblages and the regional Holocene stratigraphies (Vento et al., 1988). In sum, Neuman (1989) viewed the T-1 landform as a broadly monolithic landscape modified by successive phases of soil development sealing in stable surfaces.

Phase III

The Neuman (1989) pedogenic model underscored the pervasiveness of sealed, Cambic horizons across the site and the difficulties in isolating depositional variability across the landscape. The only acknowledged indicators for disruptions in the pedogenic and alluviation regimes were the uneven thicknesses of sola, and speculation that a "possible buried stream bed" was responsible for a subsurface concavity and groundwater accumulation between units 3 and 4 (see Neuman 1989: 46 and Figure 24).

Phase III geoarcheological efforts represented a more comprehensive effort to link landform evolution with the changing Susquehanna stream regimen, floodplain morphology and buried soil stratigraphy. Cremeens (1993: Chapter VI and Figure 22) structures a "geomorphic history model" charting seven stages in terrace development since 7000 B.P. The model integrates all aspects of floodplain/terrace evolution including floodplain aggradation through lateral and vertical accretion, stabilization of surfaces through soil formation, and erosion of existing surfaces. Most significantly, the study recognized the eastward migration of the channel over the course of the Holocene. As discussed in our report, this was probably the most critical development in the evolution of the archeological landscape. Finally, the model attempts to index the duration and magnitude of alluvial cycles by drawing upon climatic schemes reconstructed from local and regional pollen sequences (Cremeens 1993: 124).

Laboratory analyses in support of the Phase III model are exhaustive and include particle size analyses, organic matter assays, pH, radiocarbon dating, micromorphology, and bulk density analyses. All samples were taken from columns along the block excavation units (Cremeens 1993: Appendix A). The block profiles are stratigraphically separated by pedogenic units and "strata", the latter presumably referring to excavation levels. The 16 individual block stratigraphies are never directly integrated into a composite site sequence and there is no set of profiles that link up the excavation units, primary depositional units ("litho-strata"; see Cremeens 1993: Figure 17, missing), and soil horizons ("pedo-strata"; see Cremeens 1993: Figure 18, missing). A model of site formation (Cremeens 1993: Figure 19) offers a complex reconstruction of landscape change that is at the same time highly detailed, but difficult to follow in the absence of site-wide synthesis of stratigraphy and analytical data. While radiometric dates from a data bank of 47 determinations were obtained to document the chronology (Hart 1993: Table 47), the contexts of these dates are impossible to track in places; the block stratigraphies with radiocarbon dates deleted (see Cremeens 1993: Appendix A) confounds attempts to follow the complex sequences. Finally, evidence in support of intricate pedogenic process--specifically fragipan formation--is addressed in cursory fashion only, with limited supporting data.

The Phase III geomorphic history model (Cremeens 1993: Figure 22) attempts to reconstruct threshold changes in landscape evolution over the course of the Holocene. Most of the key changes were verified by the present study. Accordingly, the Cremeens model posits that the most dynamic stream environments at

Memorial Park--those most different from those of the present--existed before 6800 B.P. At this time the eastern portion of the site was incising and the western landscapes were actively aggrading. The active channel of the West Branch was apparently entrenched in the terrain presently comprising the northeastern portion of the site landform. It was flanked by the then active floodplain (T-0). Between 6000 and 4750 B.P. the channel and floodplain infilled as the channel migrated eastward, and by 3000 B.P. the near level, contemporary contours of the T-1 had been established on the western portion of the site (Cremeens 1993: Figure 22). Overbanking was the dominant sedimentary process since 6000 B.P., disrupted by periods of soil formation. Seven principal soils were recognized and dated through a combination of feature charcoal dates and humic acid radiocarbon determinations.

Cremeens' (1993: Figure 21) soil formation sequence may be only loosely correlated with that of Neuman (1989). Whereas Neuman (1989) has identified six soils up to 5000 B.P., Cremeens recognizes only three. Significantly, Cremeens describes three additional soils between 5000-7000 B.P., a time frame antedating the earliest deposits isolated by Neuman. Correlations are complicated by the absence of radiometric controls in the Neuman sequence and "out of phase" soil identifications despite excavations of up to 3 m by both researchers. The Cremeens model further addresses the variability in site stratigraphy by differentiating better developed "B-horizons". He isolates Argillic ("Bt") and Fragic ("Bx") horizons where Neuman observed only Cambic ("Bw") variants.

Correlations

Problems in reconciling the archeological and geomorphic histories of the Memorial Park site stem initially from the fact that depositional histories were generally underemphasized by both the Phase II and III studies, while soil chronologies initially overcompensated for this deficit. Soil sequences, in turn, are difficult to correlate because of the absence of radiometric controls (Phase II), the poor context of dates (Phase III), and a general incompatibility between the soil chronologies generated for the two phases.

Second, the archeological data in Phase III, one of the more massive data sets retrieved anywhere in the Susquehanna Valley, is never integrated first within the stratigraphies and ultimately within the comprehensive geomorphic model generated for the site. The archeological accounts map a broad range of anthropogenic deposits that were both spatially extensive as well as stratified in the soils and sediments of Memorial Park (see for example Hart 1993; Figure 130). These range from what appears to be an extensive Clemson Island midden to isolated Middle Archaic hearths. Within the population of 253 features a broad array of structural remains, post molds, post pits, storage pits, hearths, and variously shaped fire pits were identified (Hart 1993: Chapter VII). Activity loci were spatially and temporally clustered across the landscape (see Hart 1993: Figure 130). However, problems of anthropogenic sedimentation are never addressed. While broad correlations between site assemblages and lithostrata and pedostrata are proposed (see Cremeens 1993: Figure 20), there is no map depicting contemporaneous landscape segments and prehistoric activity loci. Accordingly, a diachronic model "mapping on" changing landscape availability with occupation areas remains to be formulated. Such a model would integrate patterns of landscape evolution with the spatial and stratigraphic information obtained by the block excavations. This is one of the end products of the present report.

Fortunately, much of the archeological and stratigraphic data needed to formulate such a model is contained in the existing reports. Table 3-1 synthesizes the existing site-landscape data contained in previous reports, updated by new geoarcheological information collected for the present study. The Table is structured by prehistoric period (Column 1) and incorporates the primary archeological distribution data (Column 2; from Hart 1993), initial soil-stratigraphy (Column 3; from Neuman 1989), composite landscape history (Column 4; from Cremeens 1993), and finally dated geoarcheological contexts reported in this report. The latter refer specifically to dated soil-sediment complexes and landscape elements chronostratigraphically equivalent to discrete prehistoric components. Reference is made to either dated prehistoric features or dated soils, surfaces, or landscape features (i.e., flood chutes, buried "A horizons," etc.). For example, for the Late Archaic this study confirmed that since dated deposits were obtained largely from a raised, centrally located buried

Table 3-1: Geoarcheological Contexts of Archeological Features and Equivalent Dated Deposits

Prehistoric Period	Archeological Distributions*	Soil Stratigraphy (Neuman, 1989)	Landscape History (Cremeens 1993)	Geoarcheological Context **
Recent	Throughout site (isolated, plow disturbed)	Soil 1	Periodic alluviation associated with cultivation, airport construction and mechanical filling; limited erosion	Flood sands and isolated humic profiles ("A-C horizons") throughout site
Historic (A.D. 1650-1920)	Diffuse and dispersed	Soil 1/Soil 2	Historic cultivation	Base of historic plow zone (Apb)
Late Woodland (1200-400 B.P.)	80 discrete features, house patterns, high artifact density	Soil 2	Cyclic alluviation and erosion (?)	Extensive sheet midden interdigitating with uppermost "Ab" horizon; variable 10-40 cm thickness everywhere, except where truncated by historic plow zone (Apb; see above) or where mechanically stripped
Middle Woodland (2000-1000 B.P.)	2 or 3 features; localised and confined to Block 7	Soil 2/ Soil 3	Dominant erosional interval on east side of site followed by lateral accretion and formation of Soil 1	Northeastern portion of site only; associated with cumulic soils (Ab/Bw interface or upper Bw horizons); linked to overflow chutes and channel migration
Early Woodland (3000-2000 B.P.)	1 or 2 features; very diffuse	Not Identified	As above, but with dominance of erosion	Diffuse throughout site. In older (western) landform segments associated with profiles developed on overbank alluvium. In eastern areas correlated with channel edge landscape (possible secondary context)
Terminal Archaic (4000-3000 B.P.)	98 features occurring across landscape; all features are fire-related; Orient phase midden on western part of site	Soil 3	Periodic overbanking, splay deposition; lateral accretion on east side of site; localised erosion and formation of Soil 2	Two clusters in western and southern portions of site; typically associated with cumulic profile (AB horizons) developed on channel edge overbank deposits of older landforms; overlooks middle Holocene channel
Late Archaic (6000-4000 B.P.)	68 features clustered on western portion of site; levee utilized infrequently; low intensity utilization	Soil 4/ Soil 5/ Soil 6	Uppermost (4500 B.P.) horizons register slow alluviation and development of Soil 3; deposition more intense on east side; earlier (6000 B.P.) strata register high energy stream flows and extensive incision of older surfaces; mild aridity as Soil 4 forms	Dominant in western portion of site with limited distribution on east; former levee locations overlooked northeast channel and overflow chutes to west; occurrence in "A" horizons developed over sandy (lateral accretion) alluvium
Middle Archaic (8000-6000 B.P.)	2 features on western portion of site; limited cultural materials; tool maintenance stations	Not Identified	West side: Buried Soil 7 on stabilizing floodplain; rapid lateral accretion (7000 B.P.) followed by stability, Soil 6; site-wide overbanking and incision of older ridges, channels, culminating in stability, Soil 5. East side: Incision, then alluviatiation	Isolated location in west-central, older landform segment; stream deposits correlate with upward fining sequence and migrating channel
Early Archaic (10,000-8000 B.P.)	Not Identified	Not Identified	Alluviation of levee/point bar by meandering channel. East side: incision, channel migration	Western portion of site only; channel fills and oldest overbank alluvium north and east of oldest Pleistocene sediments comprising former Port Huron terrace surface.
Paleoindian (>12,000-10,000 B.P.)	Not Identified	Not Identified	Not Identified	Channel gravels and organic lag deposits forming uppermost deposition of Port Huron terrace; western end of site only

* Abstracted from Hart (1993)
** From this report

surface flanked by a former levee and flood chutes, the extent of Late Archaic activity would be confined to this portion of the site.

On a period by period basis, the following observations can be made:

1. Paleoindian sites are unlikely to be preserved since they are contemporaneous with the deposition of the high discharge, terminal channel deposits of the Port Huron terrace (T-1).

2. Occurrences of Early Archaic deposits are only slightly more probable, since available surfaces remained confined to the western end of the site in a spatially confined belt of overbank sediments. However, none of the excavation efforts produced artifacts of this age.

3. Middle Archaic loci are most probably confined to central portions of the site, given that extensive lateral accretion alternately eroded and buried various segments of the landform as the channel migrated. This left only isolated islands available for occupation.

4. Late Archaic activity areas are considerably more plentiful and articulate with a laterally variable, but generally aggrading landform in the central western portion of the site. The soils dated to this period are more extensive and suggest a more extensive, level terrain less prone to inundation.

5. Terminal Archaic settlement loci are the most widely dispersed and intensive across the site landscape, but dates and sealed sediments are confined to central-western areas. This suggests either changes in adaptive strategies or a more complex landscape history than indicated by the landform setting.

6. Early and Middle Woodland loci are few and far between. They are linked to elevated Late Holocene land surfaces and seasonal drainage features in the eastern end of the site. The paucity of remains may be a function of adaptive strategies as well.

7. Late Woodland deposits are prolific and associated with a period in which the contemporary landform contours were established. It is possible that occupation at this time was associated with a sedentary adaptive strategy at a time when the landscape had evolved into a well drained setting.

By restructuring the observations of the previous studies--in this case explicitly linking geomorphic observations with the broad archeological distributions--it is possible to isolate spatial and temporal trends in the Holocene occupational history of the Memorial Park site. Second, systematic distributions of prehistoric materials mirror the complex landscape changes that have characterised Memorial Park over the course of the Holocene. Third, these observations form the basis for a conclusive assessment of the archeological potential of the Memorial Park site laterally and vertically. The following report produces such an assessment.

CHAPTER 4: RESEARCH METHODS

The original Scope of Work stressed the need to describe the pedological and geomorphological history of the site by refining cultural and archeological stratigraphies from the Phase II and Phase III reports (SOW 1993: 6). Towards this end the primary field strategy was the description of ten (10) deep trenches adjacent to or overlapping the Phase III block profiles. Subsequently, a comprehensive site stratigraphy was developed based on field observation, laboratory analysis, and the correlation of formal stratigraphic units first, across the site landscape, and ultimately through integration of the sequences generated during the Phase II and Phase III studies. Development of a comprehensive site stratigraphy was perhaps the most complex issue, first, because of the diverse, often non-standardized criteria applied by archeologists to develop cultural and natural sequences; and second, because two previous stratigraphic frameworks had already been applied to the study area (Cremeens 1993; Neuman 1989).

In this section, the three major components of the research--field studies, laboratory analysis, and site stratigraphy--are discussed in general terms. The objective is to outline the general methodologies followed. Specific field observations, data collection and analysis methods are examined in further detail in appropriate discussions of results and geoarcheological synthesis (Chapters 5 and 6).

Field Studies

Figure 3-1 illustrates the placement of the blocks and the Deep Test units. Locations of the GAI excavation blocks as well as those of the Phase II units are shown as nearly as can be determined. All of the major GAI excavation blocks correspond to at least one Test Trench with the exception of Block 1; field stratigraphy of that block was registered as similar to that of Block 2, corresponding to our T-1 (compare Cremeens 1993: Figures A-1, A-2). Trenches 3, 8, 9, and 10 were not linked to any excavation block. These flank the southwestern (T-3), southeastern (T-8), northwestern (T-10) and northeastern (T-9) margins of the archeological site. These trenches facilitate assessments of cultural and natural strata outside the excavated site locus; they were critical in determining the extent of deeply buried archeological materials not examined in the previous phases of work. Presumably, the deposits in the outlying trenches are more alluvial than anthropogenic and may help to chronicle the sedimentary environments prior, during, and subsequent to periods of human occupation (see Chapter 6).

In the field, inspection of each of the backhoe trenches was undertaken by one or both of the two Principal Investigators. Field assistants aided in the performance of descriptions, photography, sampling, and mapping of all profiles. Typically the west face was selected for primary descriptions and sampling purposes. When field relations warranted, additional faces were examined. Backhoe trenches were 6 m in length and 1.5 m in width. Depths of trenches were minimally excavated to 2.5 m and in most cases they extended to 3-5 m. In instances where depths in excess of 2.5 m were attained, observations were made from the edges of the stepped trenches. Critical radiocarbon specimens from the deepest exposures were obtained from the backhoe shovel and indexed to provenences recorded in the stratigraphy. In this way it was possible to obtain ages for critical deposits at depths marking the Pleistocene/Holocene interface; this was also a provision of the SOW (1993: Task 5). The deepest backhoe excavations extended to >5 m and Pleistocene sediments were identified in five (5) of the trenches (T-3, T-4, T-5, T-6, and T-7; see Figure 4-1 and associated radiocarbon dates).

In the field, stratigraphic nomenclature was standardized between the Principal Investigators prior to establishing working stratum and soil horizon designations. These were modified after all trenches were examined and laboratory analyses were completed. In the field, the most appropriate units of description were pedo-strata or soil horizons. This is because the preponderance of profiles preserved broadly similar parent materials--typically overbank or poorly differentiated lateral accretion facies--that were best segregated by degree of weathering. Since the Phase III study also applied this nomenclature, it was the most direct means for correlating sequences between the two studies. Subsequently, a broader chrono-stratigraphic framework was applied to distinguish depositional events and time-lines (see discussion below).

The first two trenches (T-1 and T-2; see Figure 4-1) provided the baseline sequences for standardizing the soil and depositional stratigraphy. Sampling and mapping concentrated on isolating key depositional units when possible and on tracing soil horizons across the site. This involved identifications of "A", "B", and "C" horizons to document facies variability (in "C" horizons) and patterns of weathering (in "A" and "B" horizons); selection of grain size samples to isolate depositional variability; procurement of penetrometer readings to measure compaction of finer matrices; selection of "Bw" and "Bt" horizons for geochemical and micromorphological specimens; sampling of soil humates in "Ab" and "AB" horizons for radiometric dating; and removal of charcoal from cultural features and stains for radiometric dating. Significantly, features and bulk organic sediments were taken from "Bt" horizons indicating broad preservation of organics and evolution of "cumulic soils" (see Ferring 1990; Chapter 6) in most subsurface contexts at the site. At all ten (10) trenches detailed soil-sediment descriptions were undertaken that included identifications of color (Munsell readings), structure, texture, ped development, mottling, stoniness, roots, cutans, and soil and sedimentary inclusions.

Laboratory Analysis

Table 4-1 is an inventory of the samples collected at the site by Trench number and analysis performed. As shown, a total of 16 radiometric samples were submitted for analysis, including feature charcoal and bulk soil humates. Geochemical testing was performed on three complete columns (T-1, T-6, and T-10). Composite granulometry (three fraction: sand, silt, and clay) was performed on these same sequences to determine changes in channel activity and floodplain sedimentation along the West Branch (Folk 1974). Sand size fractionation was undertaken for T-1, T-3, T-7, and T-10. This test was especially diagnostic of discharge during cycles of lateral accretion and overbanking. Penetrometer analysis isolating compaction was conducted on "Ab" and "Bt" horizons as an alternative to bulk density. This strategy helps to determine the degree of soil formation and to differentiate pedogenic and diagenetic processes acting on the sola. Micromorphology was performed on column samples from T-2. This is possibly the most precise technique for charting weathering

Table 4- 1: Inventory of Soil-Sediment Sampling

TRENCH (GRA)	RADIOCARBON	GEOCHEMISTRY	GRANULOMETRY I (COMPOSITE)	GRANULOMETRY II (SANDS)	MICROMORPHOLOGY	PENETROMETER	TOTAL
T-1	1	25	25	_	_	14	**65**
T-2	2	_	_	12	6	11	**31**
T-3	1	_	_	10	_	10	**21**
T-4	3	_	_	15	_	15	**33**
T-5	1	_	_	_	_	_	**1**
T-6	2	19	19	_	_	15	**55**
T-7	1	_	_	12	_	7	**20**
T-8	2	_	_	12	_	12	**26**
T-9	2	_	_	10	_	10	**22**
T-10	1	15	15	_	_	15	**46**
TOTAL	**16**	**59**	**59**	**71**	**6**	**109**	**320**

patterns in a vertical sequence (Courty et al., 1989).

Column sampling to isolate vertical variability was based on the potential of a profile to inform on sedimentation and soil formation histories. Also since the Memorial Park terrace was a highly differentiated surface, particular elements of the landscape were selected to register changes in landscape development not visible from surface relations. For example, T-1 disclosed a comprehensive package of sediments that preserved the complete middle Holocene sequence, as well as overflow Late Holocene channel sediments; T-10 contained the only sequence documenting contemporary levee sedimentation. Both were sampled to establish the chronology of flooplain segmentation, or the evolution of particular microenvironments within the general alluvial landscapes .

After samples were taken, they were submitted for analysis to the Soils and Physical Geography Laboratories at either Clarion State University or the University of Wisconsin-Milwaukee. For sedimentological analysis, dry and/or wet sieving segregated size grades within the sand fraction (Granulometry II in Table 4-1), while the hydrometer method separated the broader sand, silt, and clay fractions (Granulometry I in Table 4-1). Particular emphasis was placed on the sand fraction analysis due to the field evidence for changes from lateral to vertical accretion through time and across the general T-1 landform. To isolate variability within the size frequency distributions, a series of statistical parameters were also examined. In addition to standardized size grade fractionation, parameters of sorting (So), skewness (Sk), and kurtosis (Kg) were calculated using the method of moments (after Friedman and Sanders, 1978).

A battery of quantitative geochemical tests were applied to soil horizons to obtain signatures of both weathering on the terrace and evidence for human occupation in the form of disaggregated cultural residues. Varying contributions of organic and chemical elements are often associated with formerly stable surfaces that may have sustained prehistoric occupations. This was most apparent for the Late Woodland/Clemson Island component where a midden was present as well as for the earlier Late and Terminal Archaic components that were preserved in more subtle "AB" or even "Bw" and "Bt" horizons. It might therefore be possible to pursue hidden cultural signatures geochemically. The elements, or ions, tested to identify weathering and anthropogenic additions to the profile included calcium (Ca), magnesium (Mg) potassium (K) and phosphorous (P). The most common cultural residues isolated by these ion tests are bone, wood ash, excreta, and animal meat and tubers (Cook and Heizer 1965; Anderson and Schuldenrein 1985; Kolb et al., 1990; Schuldenrein 1989). To examine the degree of weathering and oxidation/reduction in the three different sola (i.e., "Bw", "Bt", or "Bx"), relative concentrations of mobile iron (Fe) and Manganese (Mn) were measured along with organic matter (OM) and pH. Covarying trends can help to determine if vertical changes in the profile are attributable to soil forming processes, human inputs into the sediments, or combinations of pedogenic and anthropogenic transformations to the matrix.

Stratigraphy: Terms and Definitions

The application of several terms and concepts must be clarified in this study because of the emphasis on stratigraphy and the need to correlate sequences with those applied during Phase II and Phase III. Since a major objective is the development of a model of prehistoric landscapes, rather than generating a broad-based stratigraphy, it is necessary to stress the prehistoric surface as the most critical component of the archeological environment. Second, since soil horizons were obvious indices of correlation across the landscape, pedo-strata are broadly utilized, although these are not baselines for the depositional history. The latter are structured around geological units, which identify the key breaks in the history of floodplain/terrace formation. Finally, chronostratigraphic units are, in fact, the baseline for the Memorial Park sequence, since the broad array of dates facilitated mapping of time transgressive units across the segments of the site landscape.

For the present purpose, surfaces refer to the tops of geological units; they represent the uppermost accumulations of sediments or soils of a given sequence. They also imply a period of stability during which minimal deposition occurred. Surfaces may refer to either the present landforms--in this case the near-level top of the Port

Huron terrace, the T-1--as well as to tops of buried landforms sealed in by past sedimentation. The buried surfaces were obviously registered in the backhoe trenches. Second, geological units, or more accurately lithologic units, are formally designated "....three-dimensional bodies characterized by the general presence of a......(dominant)......lithologic type, or by the combination of two or more of these types" (Gasche and Tùnica 1983: 328-329; see also Stein 1990). The principal lthologic units at Memorial Park are represented by a variety of stream deposits. These include channel fills (Pleistocene/early Holocene gravels and lags), lateral accretion sediments (laid down by the early Holocene migrating stream), overbank fines (produced along the later Holocene floodplain and infilled chutes), cultural sedimentation (i.e., the Clemson Island midden), and interdigitations of all these sediment types.

As implied in the preceding discussion, at Memorial Park differentiation between geological units is based on discontinuities in flooding regimes. For example, the transition between a lateral accretion and overbank sequence would be referred to as a discontinuity. However, because sedimentation across the floodplain is non-uniform spatially, it is possible to have contemporaneous overbank and channel sediments. Thus geological units are time markers more than anything. Discontinuities must be linked chronologically across the landscape to mark new geological units. Often such discontinuities can only be traced over short distances because they are both episodic and localised spatially.

In the field, discontinuities are registered either by breaks in depositional pattern, also known as unconformities, or by soils that mark stable surfaces. Typically, active periods of overbanking--during which fine sands, silts, and clays are laid down--are succeeded by soil formation. A soil, for present purposes, refers to that part of the sediment that has been weathered or chemically transformed, at the top of a stable surface. Soils are divided into three master horizons: an A-horizon, the zone of humic matter accumulation that is usually darker than others in the profile; the B-horizon, or zone of mineral enrichment and weathering, typically reddest in the profile; and the C-horizon or the unmodified parent lithology (here various grades and sizes of alluvium) of the profile on which the weathering process occurs.

Ideally, the A-B-C profile seals in and offsets either a discrete flood unit or slope sediment. It should be noted, however, that most exposures do not preserve the composite soil profile; typically A horizons and upper portions of B horizons may be stripped, or exhumed, as a result of erosion. If the soil (exhumed or intact) is subsequently overridden by a new series of stream, slope or other allogenic sediments, a second geological unit is designated. Two geological units may be separated from each other by a preserved soil, or buried horizon, which is identified by a subordinate horizon; the term "Ab" is applied to a buried A horizon. Units are offset from each other by separate master unit assignments, herein noted by Arabic numerals; accordingly the uppermost unit is "1" and is underlain by "2" with numbers increasing to the base of the recognized sequence. By convention, the "1" is often deleted in an uppermost soil sequence.

Pedo-strata refer to the components of the soil horizon contained within a single geological unit or preserved between two prehistoric surfaces. This designation is unique to Memorial Park, since, with the exception of the very earliest strata--terminal Pleistocene gravels--all subsequent depositions were capped by organic occupation levels.

Finally, chrono-stratigraphic units are perhaps the most helpful in actually correlating the ages of soils, surfaces, and geological units since they refer to absolute time frames. By convention, a chrono-stratigraphic unit is ".... a body of rock established to serve as the material reference for all rocks formed during the same span of time. Each of its boundaries is synchronous...." (NASC 1983: Article 66, p. 868). Chronostratigraphic units are infrequently applied in Holocene studies because of the general paucity of dates framing a given sequence. Memorial Park is an exception because of the broad array of dates obtained for only a 5.0 m depth of deposition across a confined landscape. Thus in developing a sequence for the site, the chrono-stratigraphic unit is the single most valuable index since it links the contemporaneity of natural and cultural events.

Table 4-2 correlates the chrono-stratigraphic units across the Memorial Park

Table 4-2: Distribution of Chronostratigraphic Units at Memorial Park

Chronostratigraphic/ Geological Unit	Landscape Distributions	Depositional and Preservation Context	Soil Horizons	Radiocarbon Dates
1a	Everywhere except southwest portion of site	Post settlement sediment, capping organics, upper Plow Zone, historic overflow alluvium	PSS, A, A/Apb, Ap, C1, C2, C3	Historic; none sampled
1	Everywhere but southwest portion of site	10-40 cm accumulation of Late Woodland (Clemson Island) organic and discard debris; midden sediments; Cambic substrate; splayed sands and overflow chute	Ab, Abg, Bw, BwC; C	1220±70 B.P. (T-8) 1200±80 B.P. (T-9) 1000 B.P. (T-10)
2	T-4, T-10	Late Holocene levee and channel bank sediments; weakly weathered (Cambic) profiles; Woodland cultural strata; western site margins	2Ab, 2Bw, A-C overbank sequences	2030±80 B.P. (T-4) 2400±60 B.P. (T-10)
3	Southern to central portions of site	Inceptisol profiles developed on 40-50 cm thick overbank deposits; A-horizons occasionally truncated; abundant cultural features (Terminal Archaic), sometimes in cumulic soil context	2Ab, 2Bw, 3AB	3590±80 B.P. (T-1) 2920±50 B.P. (T-2)
4	Everywhere but levee (T-10)	Argillic profiles, southern site; Cambic profiles/northern end; most extensive soil exposed; most uniform distribution; complete sola preserved; extensive Late Archaic features &possible midden sediments; cumulic soil contexts; overbank parent materials	2Ab, 2Bw, 3Ab, 3Bw, 3Bt, 4AB, 4C	5410±80 B.P. (T-2) 5170±70 B.P. (T-6) 4930±90 B.P. (T-8) 4800±90 B.P. (T-9)
5	T-3, T-5, T-6	Lateral accretion deposits, laminar and sloping, upward fining sequences, lamellae and illuvial clay formation; isolated pockets with features (Middle Archaic?); exhumed "A" horizons; offsets lateral accretion from overbanking (6000 B.P.)	thin 3Bw, 4Bw horizons	5710±70 B.P. (T-5)
6	Southwest portion of site (T-3, T-4, T-5, T-6, T-7)	Earliest Holocene deposits, coarse sands and gravels; abrupt stratigraphic contacts and bedforms; gleyed clays and Argillic profiles; steeply dipping, clustered, and thickest lamellae; isolated features (Middle Archaic?)	3Ab, 3Bt, 3Bw, 4Bt, 4C	6990±130 B.P. (T-6) 9250±130 B.P. (T-7)
7	Southwest portion of site (T-3, T-4, T-5, T-6, T-7)	Massive imbricated cobbles and pebbles in clay-sand matrices; pockets of abrupt organic sandy lenses and redox lenticular silts and clays; possible cultural features; isolated gleyed Argillic profiles	3Bt, 4Ab, 4Bt, 4A, 4C,	10,210±90 B.P.(T-3) 13,170±190 B.P. (T-4) 10,980±120 B.P. (T-4)

landscape. For present purposes geological and chrono-stratigraphic units are interchangeable (Column 1). Landscape distributions refer to those segments of the site where a given unit is represented, either by Trench number or by area (Column 2) (refer to Figure 4-1). Depositional and preservation characteristics, including lithologic properties and broad archeological associations, are presented in Column 3. Soil horizons are identified in Column 4 and radiocarbon determinations and proveniences (by Trench number) are shown in Column 5. A total of seven (7) master geological units (numbered 1-7) are recognized. Additionally, one (1) subordinate geological unit (1a) refers to the capping historic deposits, including episodic flood sands, historic fills and buried historic plow zones.

It is stressed that master geological units <u>are</u> <u>not</u> necessarily chronologically equivalent to master soil horizon counterparts. This is because at any given landscape position a soil weathering profile may be evaluated independently of its broader geological contexts, especially in the graded floodplain/terrace terrain which preserves microenvironmental pockets that promote localized weathering. Accordingly, a flood chute that is cyclically overridden and stabilized may incorporate several stacked soil profiles within a single geological unit. A less sensitive microenvironment may only register a single soil profile in the same area. Thus, complex stratigraphies that integrate the geological and soil sequences may introduce conflicting master strata. This problem has become increasingly pervasive at archeological sites where additional chronological controls are preserved (i.e., artifacts) and detailed pedological studies provide "finer tuning" for the general (geological) sequence (see Reider 1990; Zerate and Flegenheimer 1991). In such situations it should be stressed that the soil chronology is relative, recording changes specific to the pedon or locus specific soil body, while the geological chronology is absolute and is formulated with respect to the local landscape chronology. For this reason the <u>chrono-stratigraphy</u>, monitored by radiocarbon dates, is such a valuable tool for sorting out cultural and natural sequences at Memorial Park.

In this regard, it should be noted that the Phase III study isolated the complex correlations between geological ("lithostratigraphic") and soil ("pedostratigraphic") sequences at the site but these are not available in the draft report and could not be synthesized for this report (Cremeens 1993: Figures 17, 18 missing). Therefore Table 4-2 is a composite correlation chart of all contemporaneous units, their distributions by landform, descriptions, associated soil horizons, and radiocarbon dates. It is based primarily on data accumulated in the present study and supplemented with dated soil and geological units abstracted from the Phase III block profiles (Cremeens 1993: Appendix A). It should be read from top to bottom, to index the succession of youngest to oldest sediments and soils.

CHAPTER 5: RESULTS

This attempt to synthesize the geoarcheology of Memorial Park combines a number of analytical techniques to supplement the observations made at the ten trenches. The initial phase of the project involved field descriptions of soils, sediments and erosional surfaces to develop a working stratigraphy. This was followed by a systematic program of soil-sediment sampling from principal strata and horizons. After completion of field work and preliminary assimilation of individual trench stratigraphies, the key gaps or interpretive lacunae in the sequences were addressed. Towards this end, appropriate column and/or stratigraphic samples were selected for laboratory analysis and/or dating.

Four primary analytical methods were utilized: grain size analysis (sand fraction), geochemistry and composite granulometry (jointly processed), penetrometer analysis (soil compaction and assessment of "fragic" soil properties), and micromorphology (barometer of weathering and depositional variability). Concurrently, the absolute chronology was established with the submittal of 16 radiocarbon specimens for dating. An inventory of the soil-sediments sampled is presented in Table 4-1.

Finally, a comprehensive model of stratigraphy, chronology, and landscape evolution was generated by incorporating proveniened geoarcheological data from the Stage II and Stage III studies. This section traces the changing stratigraphic interpretations systematically beginning with the initial field study, refinements through individual laboratory analyses, and calibration of chronology through radiocarbon rate determinations.

Field Stratigraphy

Over the course of three separate stages of investigation (Hart 1993; Neuman 1989; this report), a total area of 6.06 acres (2.45 hectares) was subject to intensive subsurface investigation at the Memorial Park site. The primary locus of prehistoric activity and excavation was on the south side of Water Street and proceeded to the edge of Piper Airport (see Figure 3-1). The placement of the GAI excavation blocks as well as the deep trenches broadly conforms to three linear south to north alignments immediately north of the airport. These alignments broadly conform to the latitudinal placements of the trenches and are useful for grouping stratigraphic observations along a south to north axis. Accordingly the ten trenches are aligned as follows (south to north) (see Figure 3-1):

Trenches 1, 2, 3, and 8	(southern)
Trenches 4, 5, 6, 7, and 9	(central)
Trench 10	(northern)

The field stratigraphy for the Trenches is presented in Figures 5-1a, 5-1b, and 5-1c, conforming to each of the alignments respectively. Note that Trench 4 was placed on Figure 5-1a for purposes of graphic depiction only. Individual trench stratigraphies are placed alongside adjoining GAI excavation blocks. Field stratigraphic units are identified along with key radiocarbon determinations that offset key depositional events and soil horizons. Table 5-1 summarizes the geoarcheological contexts of the individual trenches, provenienced by elevation, location with respect to GAI excavation blocks, and radiocarbon dates. Surface elevation data are also included as nearly as can be ascertained with available maps (COE 1993) and accounts of excavation and field procedures (Hart 1993).

Beginning with Band 1, on the southernmost portion of the site (refer to Figure 3-1), the western exposure at T-3 identified a six meter sequence characterized by a thick matrix of well rounded, pitted, and oxidized gravels at the base that extend up to 4 meters below ground surface. The gravels are capped by sands over which a soil formed that dated to 10,210±90 B.P. The date is the initial indication of a change in hydrographic regime at the Pleistocene/Holocene transition, where bedload deposition gave way to progressively finer grained sedimentation. Up the sequence, a series of moderate to steeply bedded lamellar horizons characterize a lateral accretion regime capped by overbank deposits in which a series of stacked Cambic soil profiles developed.

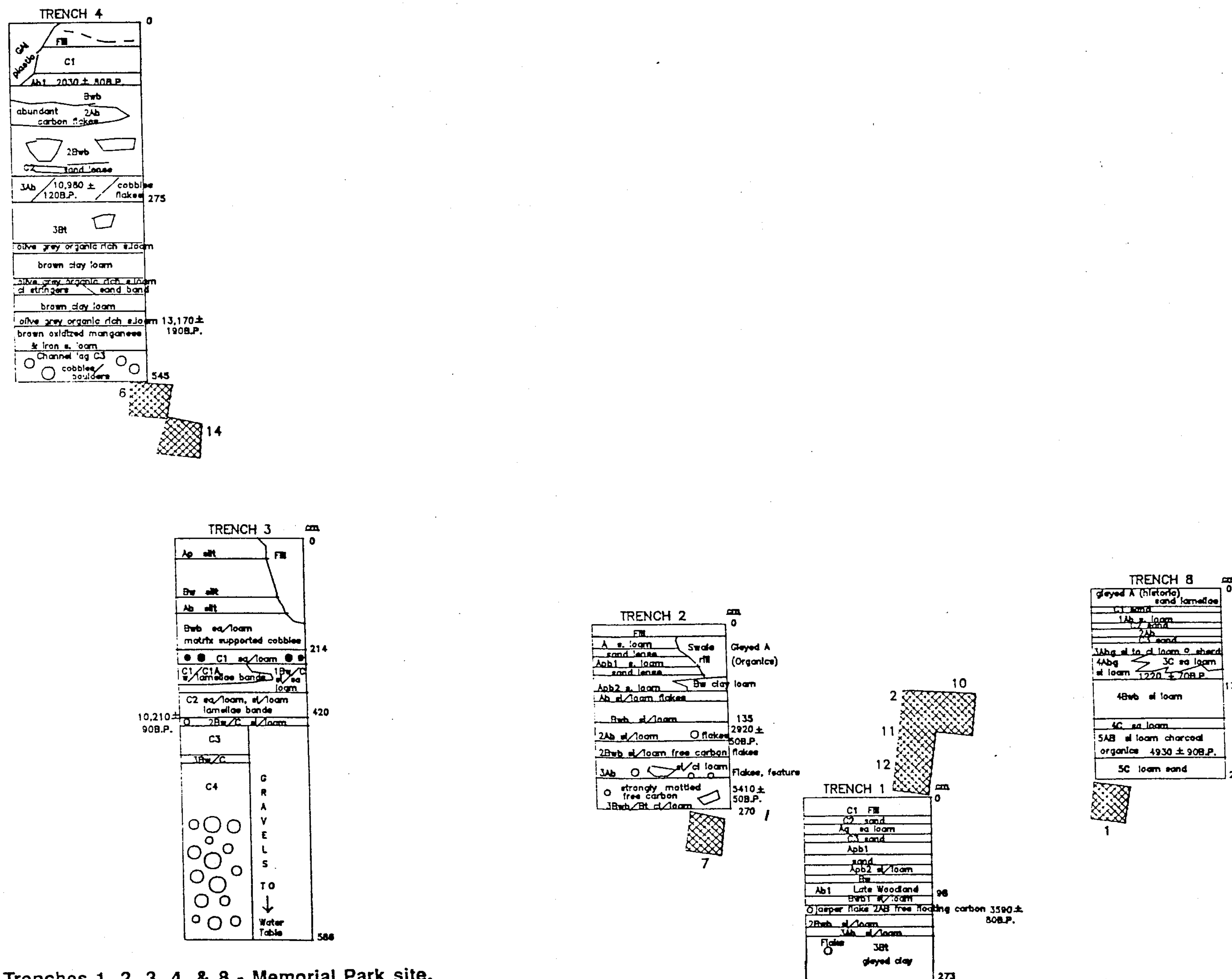

Figure 5-1a Deep Trenches 1, 2, 3, 4, & 8 - Memorial Park site.

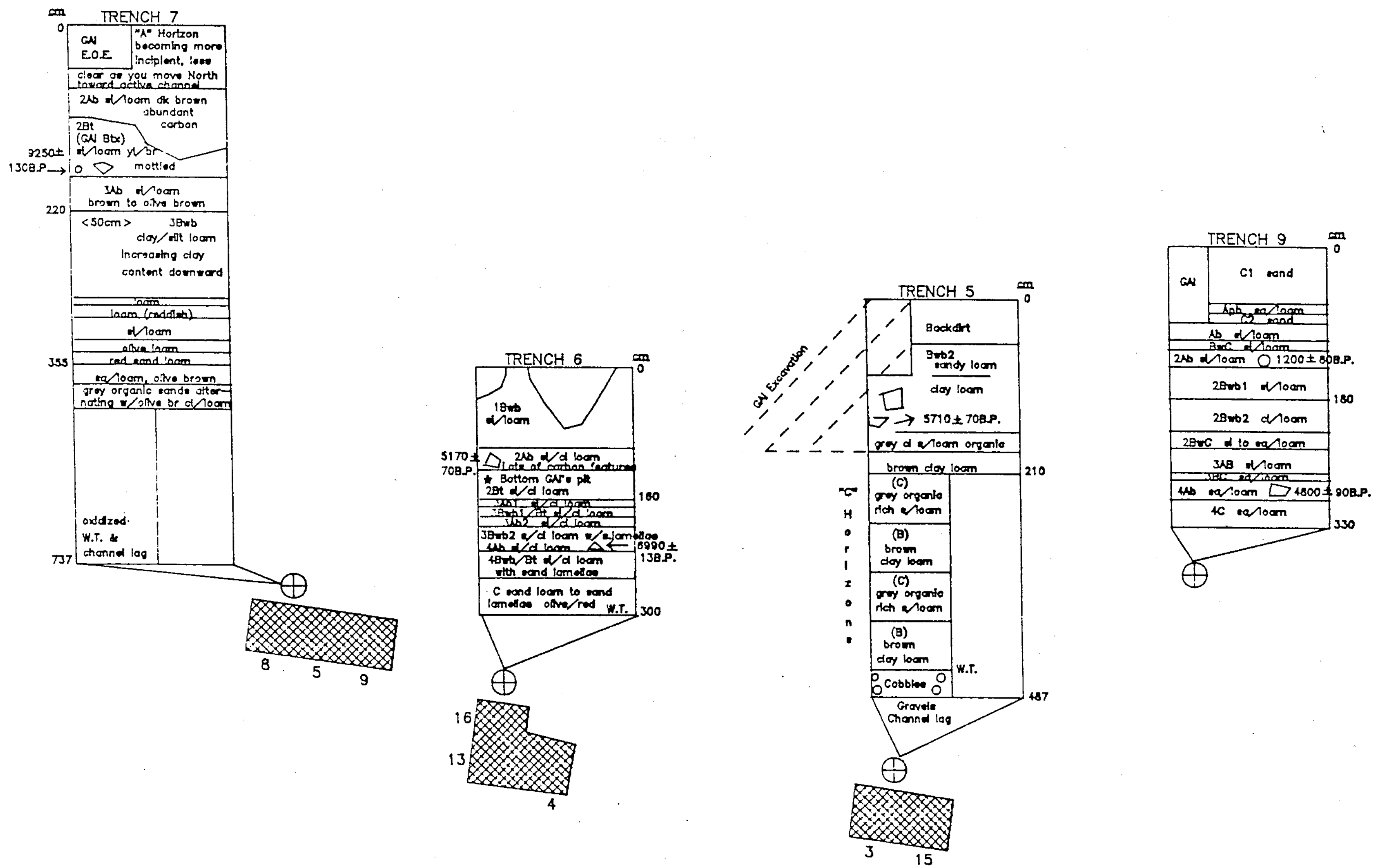

Figure 5-1b Deep Trenches 5, 6, 7, & 9 - Memorial Park site.

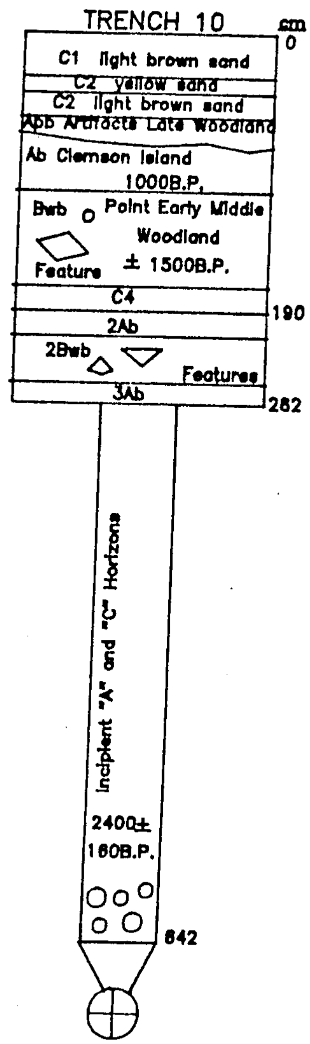

Figure 5-1c Deep Trench 10 - Memorial Park site.

Table 5-1: Geoarcheological Contexts of Deep Test Trenches, Memorial Park

TRENCH (GRA)	ELEVATION (ft.)	ADJOINING EXCAVATION BLOCKS (GAI)	RADIOCARBON DATES (B.P.)*	GEOARCHEOLOGICAL CONTEXT
T-1	554	2, 10, 11, 12	3590±80 [1.5 m]	0.5 m of historic floodsands overlie buried plow zones (Apb) truncating top of Clemson Island midden (Ab). Latter overlies weak Cambic paleosol (Bwb) and buried Late Archaic Cambic soil (3590±80 B.P.;1.3 m) Top of third paleosol identified at 2.0 m
T-2	554	7	5410±80 [2.4 m] 2920±150 [1.2 m]	Surface deposits truncated by overflow flood chute with gleyed organics to 1 m. Primary stratigraphy contains two Apb's overlying thin Clemson Island horizon. Latter stacked on second Cambic soil(2920±50 B.P.) and Argillic paleosol (3Bt; 5410±80 B.P.)
T-3	554	38 m. south of Block 6	10,210±90 [2.5 m]	Two "stacked" Cambic sequaa with minimal cultural remains; these are accumulated over fining upward lateral accretion deposits (at 1.8 m) with lamellae. Top of lateral accretion suite dated to 10,210±90 B.P. (2.8m); top of Pleistocene gravels (3.5-4.0 m)
T-4	554	6, 14	13,170±190 [5.1 m.] 10,960±120 [2.7 m] 2030±80 [1.5 m]	Mixed Clemson Island, Middle Woodland (2030±80BP). Underlain by Cambic (2Bw) and Argillic (3Bt) horizons, archeologically enriched to early Holocene soil (2.5m;10,960±120BP) (Early Archaic?);lateral accretion (3.5m) and Pleistocene gravels (13,170±120BP)
T-5	551	3, 15.	5710±70 [2.2 m]	Sandiest substrate encountered (trench prematurely collapsed). Features (undiagnostic) preserved in third paleosol (3Bt; Late/Middle Archaic; 5710±70BP); sandy channel or levee deposits extend to Pleistocene gravels (4.8m)
T-6	542	4, 13, 16	6990±130 [3.0 m] 5170±70 [2.0m]	Cumulic upper soil (poorly differentiated;2Bw) formed in overbank fines (1.0 m); early Late Archaic occupation on Argillic solum (5170±70BP; 2/3Bt?); lateral accretion deposits to 2.5 m (6990±130BP; Middle Archaic); fining upward cycles to base (3.0 m)
T-7	552	5, 8, 9	9250±130 [2.4 m]	Cumulic "A horizons" over Cambic subsoil (2Bw); underlain by Argillic soil (3Bt/fragic morphology), preserved cultural features (9250±130BP to1.7 m); Early Holocene coarsening upward sequences (1.7-2.5 m),isolated features,indicative of channeling
T-8	554	34 m. east of Block 1	4930±90 [2.4 m] 1220±70 [1.3 m]	Sandy sequence with deep Late Holocene sediments; deep historic flooding (to .7m); Clemson Island in poorly drained soil (1.3m;Abg), laterally truncated by channel splay;underlain by Cambic horizon (2Bw) and Late Archaic occupation (4/5AB;4930±90BP;2.2m)
T-9	553	34 m. NE of Block 15	4800±90 [3.0 m] 1200±80 [1.3 m]	Sandy, moderately well sorted upper alluvium as in T-8; Clemson Island at same depth (1.3m;1200±80BP); sub-horizontal overbank deposits to 2.7m (minimal artifacts);coarser lateral stream sedimentation peaks in Middle Holocene (4800±90BP; Late Archaic; 3m)
T-10	554	46 m. north of Block 6	2400±160 [5.3 m]	Contemporary levee sequence, capped by historic sands (0.6 m) above Late Woodland/Clemson Island(1.0m); Middle Woodland feature/Cambic soil (Bw;1500 BP;1.5 m); fining upward sequences to depth with two buried soils (2.7m); basal feature (5.2m; 2400±160BP)

Eastward across the landform, T-2 presents a significant departure from the relatively dynamic fluvial situation identified in T-3. Here a 2.7 m deep section exposed an upper profile (to 0.8 m) of stratified alluvial sands and silts capping buried historic plow zones ("Ap" horizons). The alluvial deposits were laid down by 20th century flood events (i.e., 1972 Hurricane Agnes). The historic sediments buried a relatively homogeneous sequence of thinly stratified "Ab-Bw" successions that contained abundant organic concentrations throughout and offset prehistorically stable surfaces and probable occupation levels conforming to "Ab" horizons. The uppermost "Ab" preserves only a portion of the Clemson Island occupation/midden. It is laterally truncated by a swale or rill feature indicative of overflow channeling, probably initiated during Clemson Island times and intermittently into the historic period. At depths of >1.3 m artifact-rich sediment matrices were encountered in each of two intact buried "Ab" sola. Two dates ranging from Woodland (2920±50 B.P.) to Late Archaic (5410±80 B.P.) bracket the sequence. The lowermost soil is identified by an Argillic soil ("Bt" horizon) displaying the most protracted weathering in the column.

To the east of T-2, T-1 preserves a largely similar profile and demonstrates the continuity of the Cambic soil successions across level portions of the landform. Here too an Argillic "Bt" horizon was preserved near the base of the exposure (2.5 m). Significantly, it contains gleyed and infilled root casts and pores as well as isolated artifacts and cultural residues. Taken together, these indicators bespeak waterlogged conditions subsequent to occupation. T-8 is the easternmost exposure in Band 1. It also represents a departure in the depositional regime, most apparent in the dominance of generally sandier sediment matrices in the lower portions of the section, a transition to finer grained overbanking, and a resumption of high level discharge. Here a middle Holocene sequence (2.4 m; base dates to 4,930±90 B.P.) has registered a series of medium sand depositions capped by overbank deposits in which the individual late prehistoric occupations are preserved. Late Archaic, Woodland, and Clemson Island components were associated with a paleosol consisting of "Ab" overlying "Bw" horizons. However, the Clemson Island horizon is at the deepest levels registered anywhere across the site (1.3 m), and substantial quantities of coarse sand has buried it; a subsurface sand splay laterally truncating the probable midden signifies at least one episode of overflow channeling around 1000 years ago.

The central alignments (refer to Figures 5-1a and 5-1b) extend about 30 m to the north of the southern, and are traversed (west to east) by five trenches. :Archeologically they contain the densest artifact and feature concentrations at the site. Stratigraphies of the western exposures (T-4 and T-7) are broadly similar to that of T-3. The basal third of the sections contain alternately oxidized and reduced gravel and clay-sand matrices of Late Pleistocene age (13,170±120 B.P.); the gravels are weak to strongly imbricated. These are truncated to the top (3-4 m below surface) by sequences of coarsening upward sands that index the Early Holocene deposition (1.7-2.5 m; 10,960±120 B.P.). Preserved cultural features at T-7 (9,250±130 B.P.) were encountered remarkably high in the sequence (1.7 m). Above this level the dominant paleosol succession across the site is preserved with two Cambic soils ("Bw"; "2Bw"; "3Bt"). All have developed "Ab" or "AB" horizons containing cultural materials. The archeological horizons invariably preserve Clemson Island and Middle Woodland features in the Cambic horizons although no diagnostics were contained in the third soil. The Late Archaic component, so prominent in eastern portions of the site was not unequivocally documented. Immediately to the east, T-6 preserves the initial evidence for a fining upward, lateral accretion regime in the form of lamellar couplets and isolated organic silt beds of Middle Holocene age (6,990±130, 3.0 m; 5,170±70, 2.0 m). Middle Holocene (and related Middle to Late Archaic) deposits are generally lacking in the extreme western exposures. At T-6, the Late Archaic time range is well represented both in terms of associated soils--upper "3Ab-3Bt" and lower "2Ab-2Bw" successions--and a progression to cumulic soils with a series of weakly differentiated "A" horizons (Entisols). The latter are developed on overbank sediments; they interdigitate with the Cambic soils in complex fashion.

Further east still, in T-5, the sandy parent materials of the upper alluvium mirror the sequence preserved in T-8. Here, however, the identification of channel gravels, that may extend to the Pleistocene previews a greater antiquity for the base of the sequence. It is provisionally related to developments on the west end of the site. At

T-5, beginning with the top of the dated deposits (5,710±70 B.P.; 2.2 m), the sets of buried paleosols, characterize the sequence to the top, although evidence for prehistoric components subsequent to Late Archaic was absent. Intact prehistoric deposits of the past 5000 years were, however, preserved immediately to the east, in T-9. Here, Clemson Island and Middle Woodland deposits were contained in an upper succession of stacked paleosols (1,200±80 B.P.; 1.3 m) developed on overbank alluvium. These, in turn, are underlain by Middle Holocene lateral accretion deposits (4,800±90 B.P.; 3.3m).

Northern site stratigraphy is registered 45 m north of central alignment and across the Memorial Park road (Figure 3-1) by a single deep test, T-10 (refer to Figure 5-1c). The significance of the excavation is that it alone documents the stratigraphy of the present levee deposits flanking the West Branch of the Susquehanna. Expectedly, the substrate are sandy and contain accumulations of moderate to well sorted recent alluvium. More striking, however, was the preservation of pristine Late Woodland and Clemson Island horizons at depths of the interface of the basal plowzone ("Apb/2Ab" horizons; 0.5 m). These topo-stratigraphic relations verify the relative stability of the present terrace bank and its limited susceptibility to flooding over the past 1000 years. With the notable exception of the 20th century floods, inundation periodicity during the later prehistoric period was relatively low (ie. the upper 0.5 m of alluvium was laid down in the past century). Buried archeological features were identified to depths of >6.4 meters where a cultural deposit was dated to 2,400±160 B.P. The sequence was a homogeneous succession of "A-Bw/C" horizons that typify high frequency cycles of alluviation, limited surface stability and an inordinately high sedimentation rate. Preliminary calculations register accumulations of alluvium of 38.5 cm/100 years between Early Woodland and Clemson Island times, compared to 12.5 cm/100 years subsequently. This amounts to a threefold reduction in alluviation over the past millennia and attests to the pre-Clemson Island dynamism of the terrace edge environment.

<u>Sand Fraction Granulometry</u>

Procedures and Sampling: For this analysis a series of vertical samples were collected from Trenches 1, 3, 7, and 10. Accordingly, a broad representation of the depositional environments across the T-1 landform was obtained. The objective of this study was to measure changes in discharge regimes, and by extension, time transgressive flooding intensity by monitoring particle size variability up the sequence.

Bulk samples of 500 grams were collected from each stratigraphic horizon at 10 cm intervals. If sediment texture or color changed within a 10 cm interval, two samples were selected, bracketing the change. Sediment samples of >500 grams were collected in the field and then formally sampled into a single 50-gram fraction, with a random sample splitter.

A standard granulometric sieve analysis was performed on the 50-gram fraction from each of the sediment columns. Wet sieving was used to determine the distribution of grain sizes within each sediment sample. Whole phi (0) sieve size intervals were used, including those of 4 mm (-2 phi), 2 mm (-1 phi), 1 mm (0 phi), 0.5 mm (1 phi), 0.250 mm (3 phi), and 0.063 mm (4 phi) size classes.

Statistical formulas were applied to calculate mean (Mz), median, standard deviation (So), skewness (Sk), and kurtosis (Kg) based on the method of moments as described by Friedman and Sanders (1978: 78-80) A detailed discussion of the strategy is presented in Appendix A.

Interpretations: Results of changing grain size distributions with depth are illustrated in Figures A-1 to A-6 (Appendix A). Figures A-7 to A-11 (Appendix A) show depth-dependent trends in the grain size parameters.

The geomorphological analysis during Phase III included a broad series of grain size analyses similar to the ones undertaken for this study. Accordingly, Cremeens (1993:93), established that the broad sediment population from most strata is confined to the loam and silt loam textural ranges of the USDA textural triangle. The focus of this study was on the > 0.5 mm fraction contained within the sand, loam sand or sandy loam fields of the USDA textural triangle. These represent the initial depositions of sediment through flooding. Sediment depositions represent autogenic events (C-horizons of variable thickness) that were once likely laid down across a given locus during a one or two-day period (i.e., "an event") in response to high flow velocities during flood stage along the Susquehanna River. The thicker, coarser-grained and better sorted the horizon, the greater the competence and capacity of the overbank event.

Analyses of the coarser fractions suggests that the fluvial regime of the river was one of great competence and capacity during the late Pleistocene and early Holocene as illustrated in the coarse grain sizes from the lower levels of Trenches 1 and 3 (Figures A-1, A-2, A-3, A-7, A-8, and A-9). These high flow velocities are related to more effective precipitation and lowered rates of evapotranspiration associated with the earliest sedimentary environments represented at the site.

Overbanking of finer sand-sized particles is registered by dominance of the fine fractions in profiles of Trenches 7 and 10 (Figures A-4, A-5, A-6, A10 and A-11). These profiles correlate with the period 11,000-10,000 B.P. and indicate reduced competence and capacitance of the river at a time when the river passed to a meandering regime. Meandering stream activity is typically a response to a graded or equilibrium condition (Schumm 1977), and in North America it has been linked to more mesic climatic conditions (Knox 1983; Vento and Rollins 1989).

The coarser overbank deposits in the upper portions of Trench 10 (Figures A-5, A-6, and A-11), at the site of the present levee, date from 4,500 yrs B.P. to the present. These probably represent large cyclonic induced flood events (e.g., 1972). In addition, the mid to late 19th century deforestation of the valley would have favored increased surface runoff and higher sediment yields, allowing for coarser-grained and larger than normal overbank events. In general, the central and upper sequences of the trenches contain coarsening-fining-coarsening sequences representing transitions from lateral accretion to overbanking at various cycles in the fluvial history of the stream (see discussions in Chapter 6).

Geochemistry and Composite Granulometry

Procedures and Sampling: The vertical limitations of deep test sampling imposed a series of constraints on the sampling of cultural and natural strata. Cultural sediments were especially difficult to isolate. This was because of problems in differentiating features and laterally extensive activity areas (i.e., middens) from a broad range of humic horizons (i.e., "A" and "AB" horizons that proliferated in buried contexts. To assess the significance of cultural residues, specimens of features were collected wherever recognized in trench exposures; anthropogenic or organic horizons (i.e., "Ab" and selective "B" horizons) were sampled when cultural "signatures" were apparent. These were included in the comprehensive geochemical and sedimentological analyses of all strata.

Interpretations: Results of the soil and sediment analysis for two representative site stratigraphic columns, T-1 and T-10, are illustrated in Figures 5-1 and 5-2. These locations were selected since they are representative of the patterns of sedimentation, weathering, and anthropogenic inputs across the site landscape. T-1 preserves the entire Middle-Late Holocene sequence with a comprehensive record of Late Archaic through historic occupation on the south side of the site. T-10 registers the unique sequence of levee sedimentation and late prehistoric occupation (Woodland and subsequent) associated with the bank edge of the terrace.

Each column depicts vertical changes in the soil profile for four discrete data sets. The first presents the soil and sedimentary profile with horizon designations noted. Immediately to the right the documented archeological components are identified. The second set of data consists of the particle size distribution (Granulometry) characterized by relative percentages (by weight) for four fractions: sands (<4Ø), silts (<8Ø), and clays (>8Ø). The third data set includes geochemical plots for phosphorous (P), magnesium (Mg), potassium (K), iron (Fe), manganese (Mn), pH, organic matter (OM), and calcium carbonate (CaCO3).

For T-1 (Figure 5-2), the top of the sequence features initially high concentrations of sands, all associated with the unmodified alluvium of the historic floods, probably

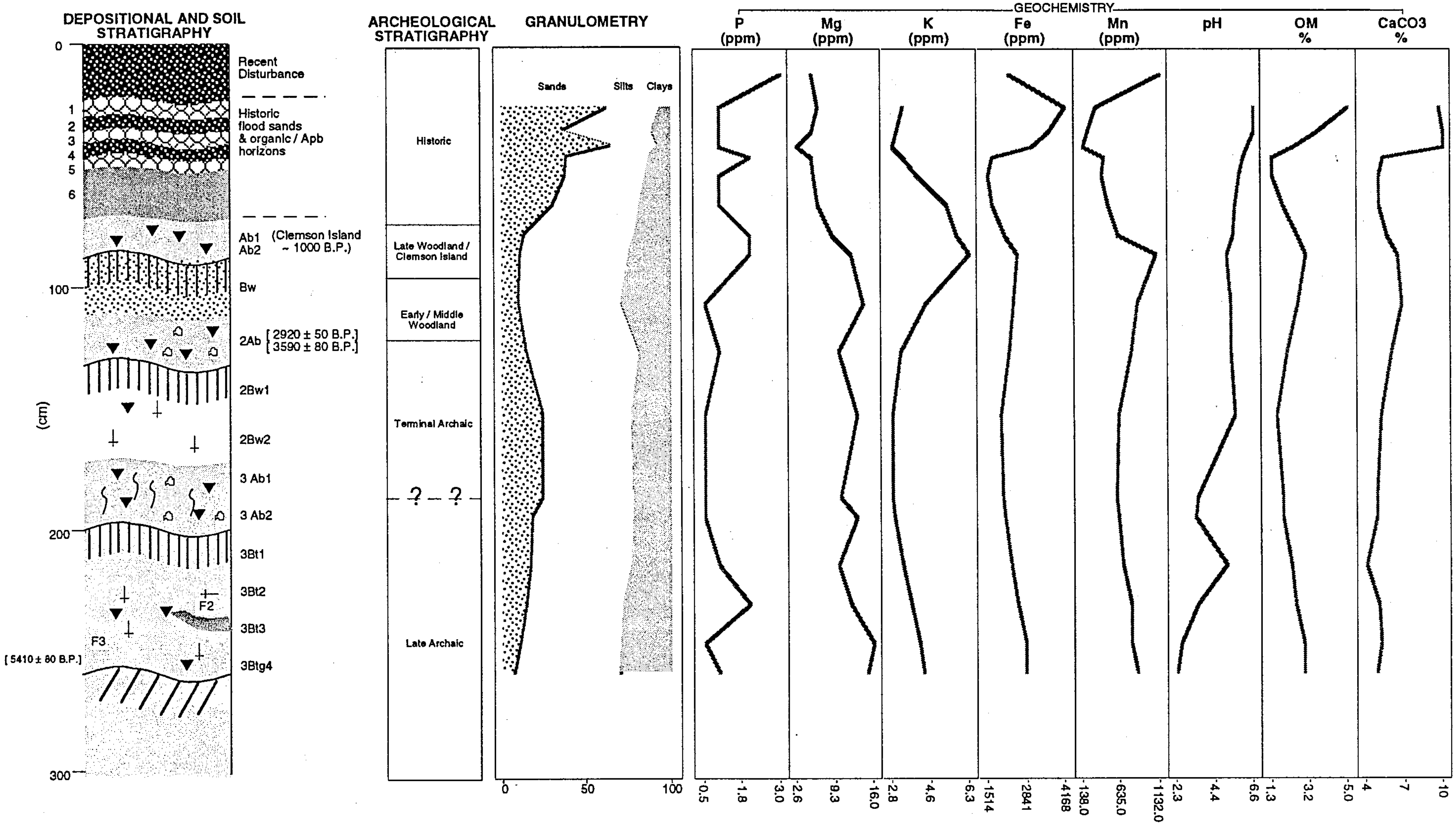

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Figure 5-2: STRATIGRAPHY AND SOIL-SEDIMENT ANALYSIS: T-1

PROJECT	DRAWN BY	SCALE
Memorial Park, Lock Haven, PA	drb	NA
	DATE	REVISION
	10/19/93	10/21/93

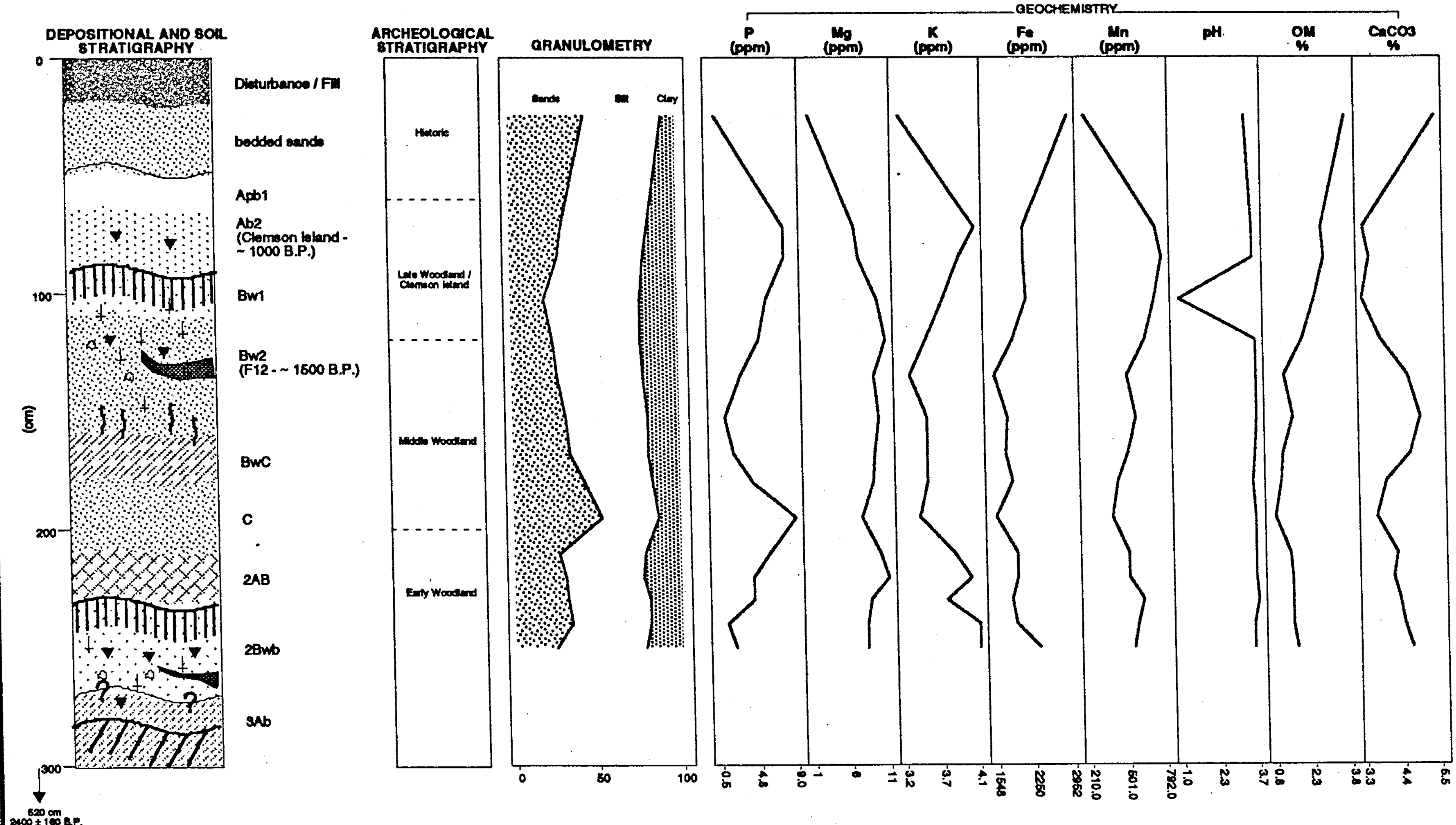
those of 1972 and 1936. Assignment of flood age is verified by informant accounts and historic records. The plow zones ("Apb" horizons) separating the alluvium contain the same general textures as the overlying and underlying alluvial depositions with limited introduction of fines linked to settling and compaction when the terrain was farmed. The first major break in sedimentology is directly related to the Clemson Island and Late Woodland components. A unique sedimentological composition is characterized by the lowest frequencies of coarse sands as well as highest concentrations of non-pedogenic clays. This may be a function of extensive land use on the terrace, perhaps related to limited horticulture or, more probably, the result of extensive trampling. Both sets of activities would result in the disaggregation and crushing of natural sediments. Since the Clemson Island occupation was the most extensive of any, prehistoric or historic, across the landform, it is not unexpected that matrices would have been widely transformed by anthropogenic process (see discussion in Chapter 6).

Below the occupation surfaces ("Ab/Bw" profiles) the grain size data reveal coarser stream deposition that fines with depth due to translocation of clays within the Late Archaic soil ("3Bt" horizons). Significantly this is a cumulic soil (see Ferring 1992), as signified by the presence of features within the Argillic horizons. The humic surface ("3Ab2" horizon) marked the most stable soil in the sequence and was responsible for "overprinting" the cumulic profiles.

The geochemical data present co-varying signatures linking weathering and anthropogenic trends. Phosphorous (P), perhaps the most diagnostic measure of cultural activity, is uniformly low. However, within the limited range peaks are discerned in the historic, Clemson Island, and Late Archaic "Bt" horizons, with less pronounced modes in the "2Ab". For the historic surfaces the peak values may reflect the input of human residues into the capping "fill and disturbance" sediment matrices; for the lower horizons, it is probable that P is a stronger measure of human occupation. The two other indicators of cultural inputs are Mg and K, both of which have prominent bulges in the Clemson Island/Woodland horizons and secondary "spikes" towards the base of the Late Archaic levels. A similar general trend is observed in the Organic Matter (OM) curve which registers enrichment of humic materials as a result of disaggregation of both vegetation and a variety of human and animal waste materials. The major index of soil weathering or pedogenesis is the changing frequency of mobile iron (Fe). Gradual increases in iron are also noted at the base of the recorded sequence, again reflecting translocation of mobile oxides as the argillic horizon reaches chemical equilibrium. Finally, the lower pH readings register progressively acidic values as a function of the incremental weathering of the cumulic soil; ongoing humification produces reduced pH values that only diverge at the base of the section when "B horizon" formation is most pronounced (i.e., depleted of acids). In sum, a variety of geochemical indicators indicate maximum levels of human activity in the Late Woodland/Clemson Island midden surfaces and progressively reduced cultural inputs in Terminal and Late Archaic horizons. The Late Archaic horizon is the only one preserving a sustained, deeply weathered soil horizon.

A considerably different sequence is preserved in T-10, since that portion of the landscape was not nearly as stable and was less subject to soil forming processes (Figure 5-3). Here Woodland occupations extend to depths in excess of 5m. The present synthesis has differentiated weak "Ab-Bw/C" soil sequaa; these may also be considered moderately expressed Entisols. Comparisons of the general textures of the parent material matrices are illustrated in Figure 5-4, the three fraction grain size distributions for T-10, T-1, and the contemporary floodplain or T-0 surface. The latter was sampled to compare contemporary aggradation patterns with those of the levee and the generally older T-1 sequence. General distributions underscore that T-10 sediment matrices contain an average of 20% more sands than corresponding levels in T-1. T-10 matrices feature a broader grain size distribution than the older T-1 sediments, with a dominant mode in the silt fraction and a minor secondary mode in the sand fraction. This distribution is partially mimicked by the contemporary floodplain sedimentology. T-1 sediments display more uniform and sandier textures. Uniformity of the grain size distribution with depth (Figure 5-4) verifies the longevity of levee formation at this location and the general stability of the landscape over the past 1000 years.

Geochemical data at T-10 illustrate especially prominent peaks in the Clemson



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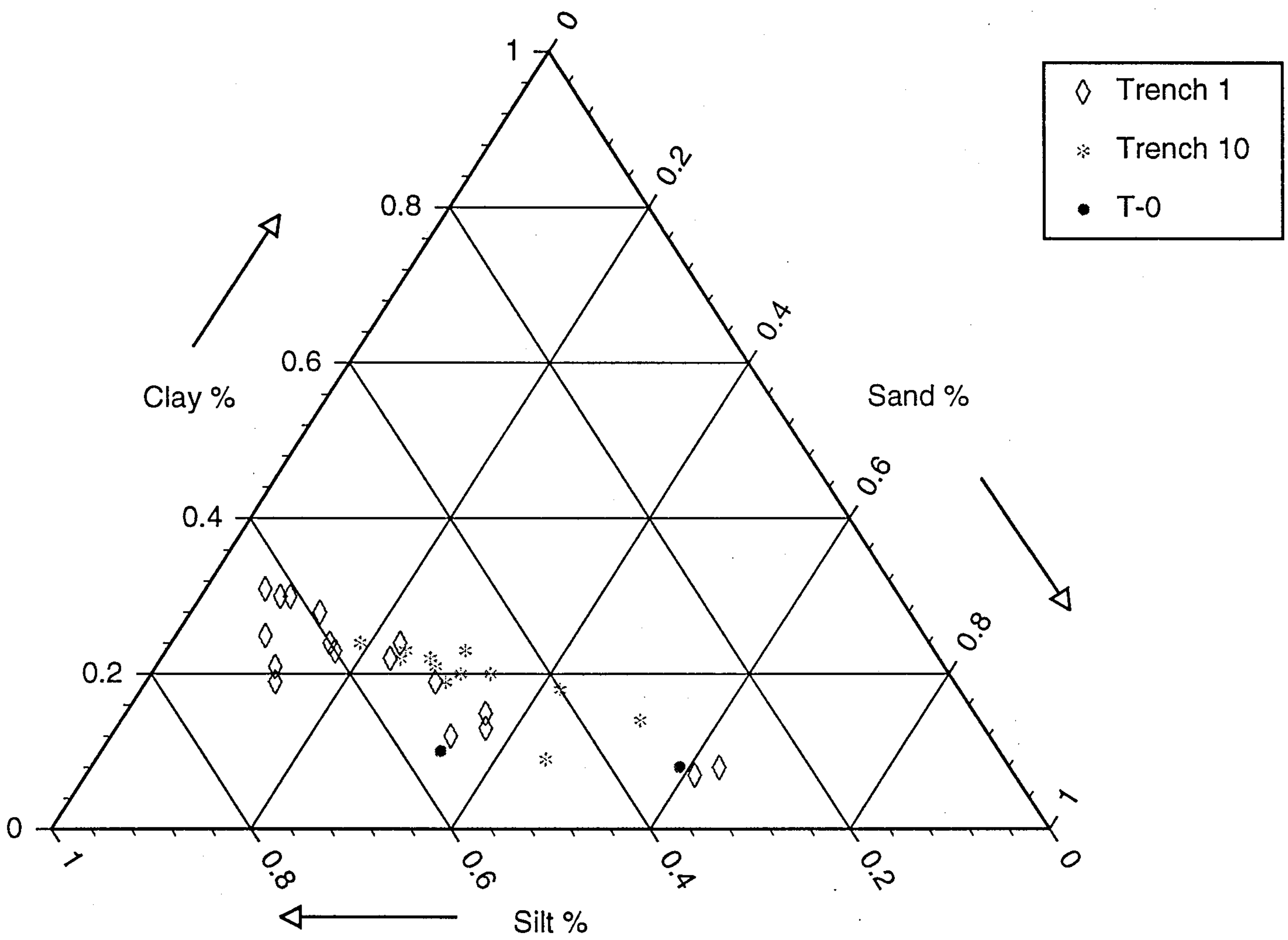
DRAWING TITLE STRATIGRAPHY AND SOIL-SEDIMENT ANALYSIS: T-10	FIGURE 5-3
PROJECT Memorial Park, Lock Haven, PA	DRAWN BY: drb SCALE: NA DATE: 10/19/93 REVISION: 10/20/93

Figure 5-4: Memorial Park: Three Fraction Particle Size Distribution



Island midden and, strikingly, at the interface of the "C/2AB" horizons, perhaps bridging the Early to Middle Woodland occupations; the significance of this bulge is not clear, although it may register the incorporation of cultural debris at the point at which the surface was buried by a subsequent alluvial episode. At T-10 the potassium (K) indicator mirrors trends in P, again showing peaks in the Clemson Island midden and Early Woodland occupation level. Mg trends are uniformly high. Iron (Fe) mobilization is more subdued than in T-1, although this indicator reflects minor peaks in the "Bw" horizons, both of which are associated with features. Organic matter (OM) trends parallel those for the anthropogenic indicators (P, K) and peak in the Clemson Island and Early/Middle Woodland horizons. Calcium carbonate concentrations for T-1 and T-10 may reflect leaching and reprecipitation in the "B" horizons, or alternatively, concentrations of bone in the features or cultural levels that may have been moderately mobilized. For T-10 the geochemical data indicate limited weathering and sustained utilization of the levee environment by later (i.e., Woodland and subsequent) prehistoric groups.

Penetrometer Analysis

Procedures and Sampling: A penetrometer study was conducted on the exposed soil horizons in Trench 6. Objectives were to determine the relative compaction (bulk density) of the soil horizons within the exposed profile. Trench 6 was chosen since it contained a "field stiff" Bt horizon--identified as "Btx" in Hart (1993)--and was overlain by more Cambic ("Bw") horizons. The major soils differentiated were the "Ab" and "Bt" horizons.

The penetrometer consists of a 1/4 inch diameter steel rod and a large spring. The rod was marked so that consistent penetrating force could be applied to the trench wall. The rod tip was left flat, while the spring was slipped over the end of the rod, which, in turn, was manually pushed into the wall by exerting force on the spring. Force was applied until the rod came to rest. Since the force exerted by a spring is proportional to the length that the spring is stretched, application of force on the spring until penetration ceases insures consistency of force exertion on the soil of the trench wall at each point on a measurement grid. The grid was laid out on the trench wall, beginning at the south end of the trench at a reference level line (zero point for vertical direction). Values above the line are positive and below negative. Ten vertical lines were laid out on the west wall of the trench at 0.5 meter intervals with the "0" meter line at the south end of the trench. Each vertical line was marked at 5 centimeter intervals. The penetration data was taken for each vertical line. For the first six lines, the data was taken every 5 cm.; for the northern four lines, the data was taken at .5 meter intervals.

Interpretations: Results of the penetrometer study for Trench 6 are depicted in Figure 5-5. They indicate that the 2Ab and 2Bt horizons in Trench 6 were significantly more compact than mapped solas stratigraphically above and below these horizons. As noted, these horizons correspond to the weakly developed or incipient Btx horizon in Hart (1993:105). Their bulk density analysis (see Hart 1993: Appendix A) led them to conclude that the soils above and below the reputed fragipan horizon on the western side of the site did not exhibit any significant difference in bulk density when compared to the Btx.

Results of the present penetrometer study demonstrate that compaction is more variable spatially than vertically. The 2Ab and ABt horizons of the western site segments are more compact than equivalent soil horizons on the northern (Trench 10) and eastern (Trenches 5, 8, and 9) site segments. This occurrence may be due to several factors. First, the western portion of the site is significantly older and more stable than the eastern and northern portions of the T-1 landform. Greater antiquity has promoted longer, more sustained compaction and pronounced weathering of the overbank deposits; frequency of overbank deposition is reduced. Second, the 2Ab and 2Bt horizons in Trenches 4, 6, and 7 indicate extensive site utilization (especially land clearing and burning activities) by the aboriginal inhabitants. Such land use may have accelerated development of stiff, waxy hydrophobic soils. These activities would have enhanced the compaction and waxy/stiff consistency of the 2Ab and 2Bt horizons. Third, the stiffer, more compact soils present in the 2Ab and 2Bt horizons in Trench 6 date to the warm-dry Sub-Boreal climatic phase (c. 4,200 B. P.-3,000 B.P.) and may document long-term desiccation and accompanying compaction of sola.

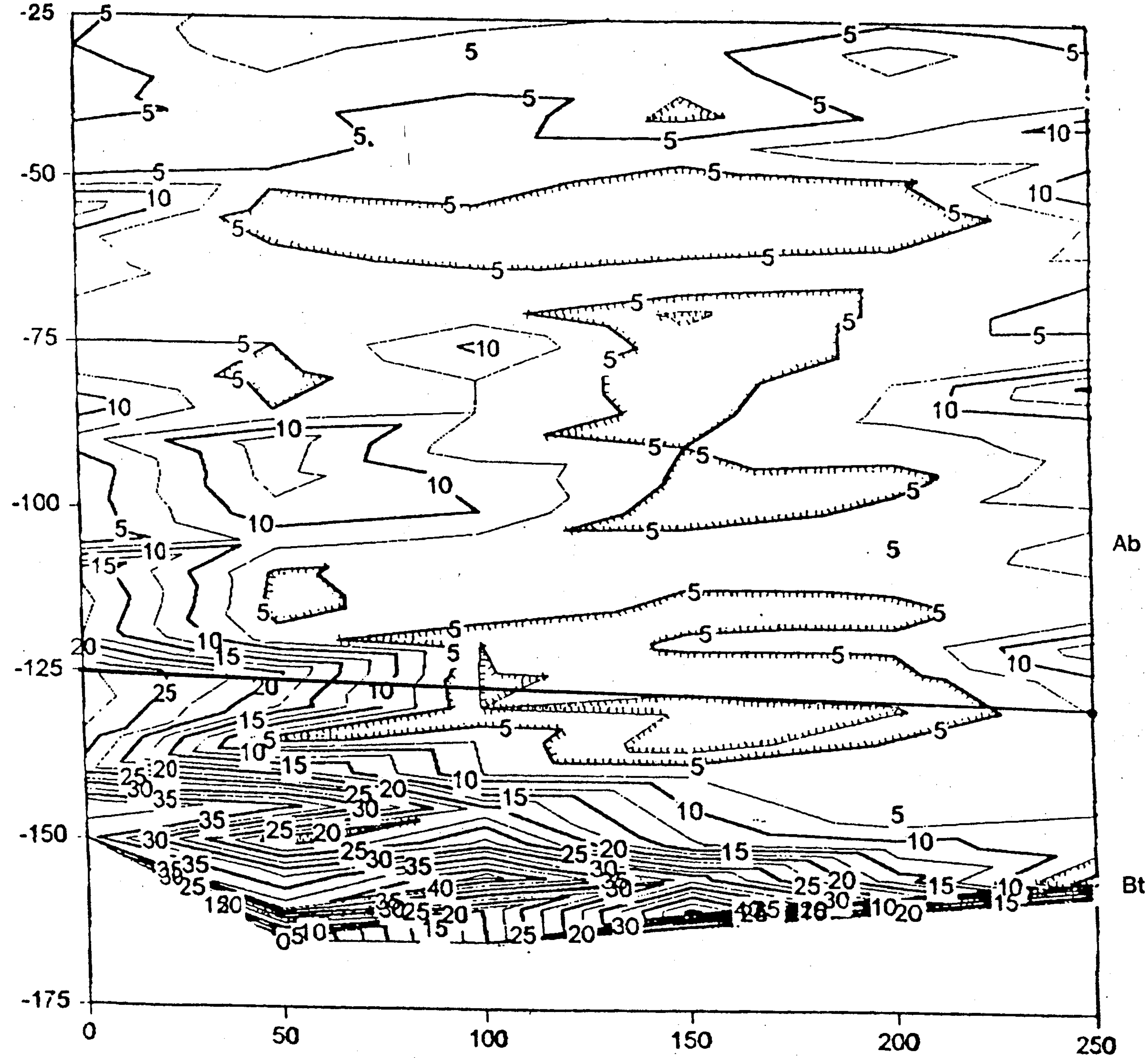


Figure 5-5 Penetrometer Readings: Ab and Bt Horizons - Trench 6

Micromorphology

Procedures and Sampling: A comprehensive micromorphological analysis was performed on soil-sediment specimens from the upper column (to 2.6 m) of T-2. The objectives were to isolate the weathering process in the Cambic ("Bw", "2Bw") and Argillic ("3Bt") horizons. A major concern was to verify the presence of possible fragic features.

Six standard size (27 x 46 mm) petrographic thin sections were prepared from impregnated, undisturbed blocks by Spectrum Petrographics, South Jordan, Utah. These were examined with a Nikon polarizing microscope in plane (PPL) and polarized (XPL) light, at magnifications ranging from 20x to 200x. Semiquantitative estimates of some of the components were based on visual comparisons with abundance charts published in Bullock et al., (1985); micromorphological nomenclature also follows this source. Detailed and formal descriptions of the thin sections are presented in Appendix B and illustrated in Plates B-1 and B-2.

Interpretations: Micromorphological analysis of Trench 2 soils and sediments verified the cyclic patterns of translocated clay mobilization throughout the profile preserved within each "A-B" solum (see Appendix B). There are higher concentrations of mobilized iron (Fe) in the lower ("3Bt") horizons. The "3Bt" also featured pronounced gleying and in deeper sections this was offset with the separate designation of a "3Btg" horizon (see Figure 5-1a).

More specifically, the following observations can be made:

1. Most of the sediments and parent material are similar from bottom to top, and presumably represent the type of material being supplied by the river. The somewhat greater proportion of medium sand in the uppermost sample is most likely a local phenomenon, without sedimentological or pedological significance. Lithological discontinuities are not evident in the thin sections. Similarly, the type and amount of translocated clay in sample 3Bt does not appear to be significantly different from that in other samples.

2. Most of the pedological processes observed in thin section are generally uniform. These are expressed principally by two types of in fillings: apleochroic reddish brown, and moderately oriented laminated clay type, and a dark brown, dusty (and locally silty) clay type. In some sections the first type is followed by the second. The first type is normally more typical of Bt horizons, whereas the second is commonly associated with translocation below exposed, crusted surfaces (Courty et al. 1989). The former, therefore, could represent an older phase of clay translocation whereas the second, dusty type could be of relatively recent origin, possibly associated with modern agricultural practices. This second phase may also form in association with the "washed" matrix observed in several of the samples.

3. Additional pedological modification takes the form of micropassage features which are produced by biological activity, although the specific agent could not be identified.

4. The most striking feature observed was the presence of extensive gleying in the lowermost sample (3Bt). It is possible that this gleying could be tied to an earlier soil-forming episode.

5. The lack of porosity in samples Ab, 3Ab, and 3Bt is striking. Such low porosities are often taken as fragic features. However, their occurrence in A-horizons may reflect on swelling and shrinking conditions related to localized oscillations in the (perched) water table.

Radiocarbon Dates

A total of 16 radiocarbon determinations were obtained from soils and sediments at the ten trenches. Specimens were processed at Beta Analytic Laboratories, Coral Gables, Florida. Provenances and stratigraphic contexts of the specimens are listed in Tables 5-1 and 5-2 and illustrated Figure 3-1. Equal numbers of specimens (n=8) were taken from archeological features and buried organics (either "Ab" or "AB" horizons). While the reliability of humic acid dates has been questioned in certain soil forming contexts (Taylor 1987) where probabilities of contamination and mixing are high, at Memorial Park close interval vertical sampling and the large number of dates from the present (n=16) and Phase III (n=47) studies afforded sufficient internal controls to determine potential for contamination. The soil organic dates correlated well with feature dates from equivalent strata and, in cases of archeological horizons, determinations fell within the range of temporally diagnostic assemblages. Temporal assignments for archeological assemblages were extrapolated from the Phase III work (Hart 1993), since only limited numbers of diagnostic artifacts were recovered during the Deep Trenching work.

As shown in Figure 3-1, the deepest dated deposits are derived from a depth of 5.1 m from gravels laid down on the terminal Pleistocene Port Huron terrace. Late Pleistocene ages were obtained for strata extending to depths as shallow as 2.5 m (in Trenches 3 and 7) on the northwestern portion of the site, while dates at the same depth to the south and east were 4,000-5,000 years more recent (at Trenches 2 and 8; compare locations in Figure 3-1). Each of the age determinations marks a discrete surface, since samples were taken either from archeological deposits or organic sediments that offset, at least, a meta-stable landscape level. These data indicate that certain segments of the landscape aggraded differentially through time. These time-depth trends provided the earliest indications of variability in the morphology and the ages of the buried landforms. The topography of the Holocene alluvial surfaces was markedly different from that of the present where near level surfaces characterize the entire T-1 surface.

To explore the relationship between buried surfaces and time in greater detail, Figures 5-6a and 5-6b plot the radiocarbon ages of each specimen with its associated depth. Variability in surface elevation was not a critical factor since across most of the site elevation differences are on the order of only 0.2-0.3 m. A correlation analysis was then run to measure the degree of depth-age correspondence. In this analysis, the population correlation calculation returns the covariance of the two data sets (age and depth) divided by the product of their standard deviations. The objective was to determine how closely the two data sets moved together. A total of 17 dates were entered into the data set. This included the 16 dates originally collected and an independent determination obtained from the Clemson Island midden.

The correlation coefficient for the complete data set of 17 determinations (Figure 5-6a) was r=0.54, indicative of weak to moderate correspondence (r=1 is the index of perfect correlation while r=0 isolates no correlation). Perfect correlation would be graphically expressed as a linear trend connecting all points in the plot. Examination of the data shows that two dates in particular account for the divergence in linear correspondence. These are the deepest dated sediments in the sequence: one is the levee location that produced an unexpectedly late date of 2,400±160 B.P. (Beta-65153) at a depth of 5.2 m, and the second is the oldest date of the sequence at 13,170±190 B.P. (Beta-65148) at a similar depth. Significantly, these two locations lie within 30 m of each other and illustrate the contrasting subsurface topographies at depths of >5.0 m.

Figure 5-6b presents the same plot of radiocarbon ages by depth with the two extreme values, or outliers, deleted from the correlation. Recalculation of the data produces a correlation coefficient of 0.79, demonstrating a trend that is significantly more linear than the composite. Closer examination of the data show that the depth of burial, as measured by the slope of the trend, is most pronounced to depths of 2.5m and subsequent to 6,000 B.P. For the Late Pleistocene/Early Holocene, a span of 4,000-5,000 years, sediment accumulations average on the order of 0.5 m (ranging from depths of 2.5-3.0 m).

Collectively, time-depth correlations and graphs indicate that the broadest variability in subsurface topography occurs at depths in excess of 5.0 m. Additionally the following observations can be made:

1. The northwestern end of the site featured the most pronounced and complex landscape changes; deep Late Holocene and Late Pleistocene alluvial surfaces are deeply buried at the same level and in close proximity to one another.

2. Early and Middle Holocene surfaces are typically buried between 2.5-3.0 m below the present surface across most of the site.

3. Late Holocene alluvial deposits are confined to depths of 1.5 m except on the northwestern ends of the site.

These observations on buried floodplain surfaces have significant ramifications for understanding the changing occupational availability of the Memorial Park terrain

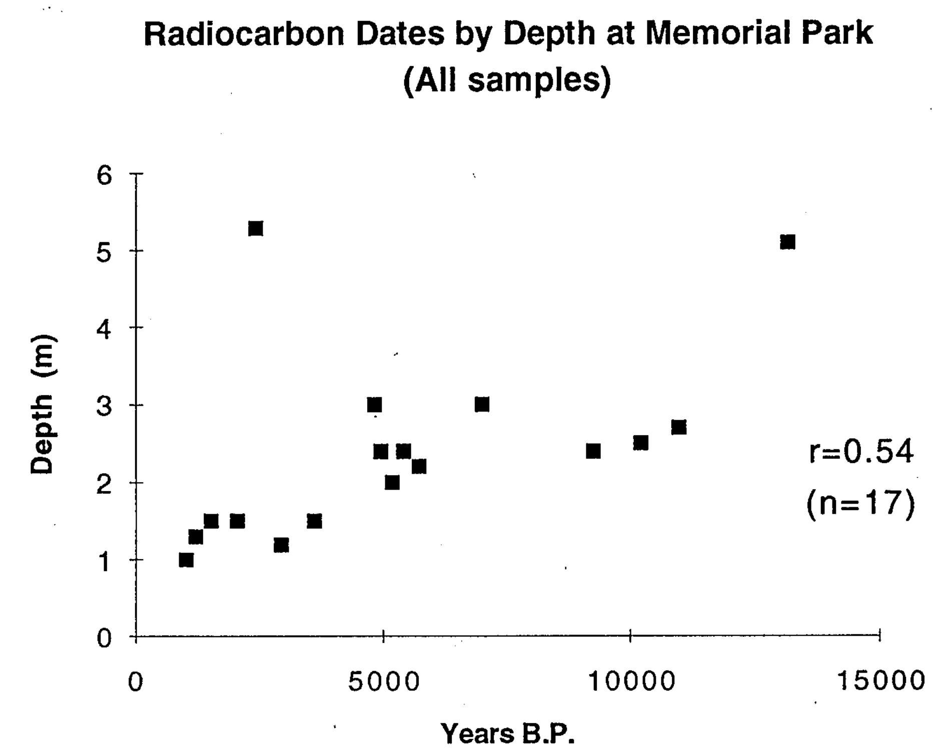


Figure 5-6a

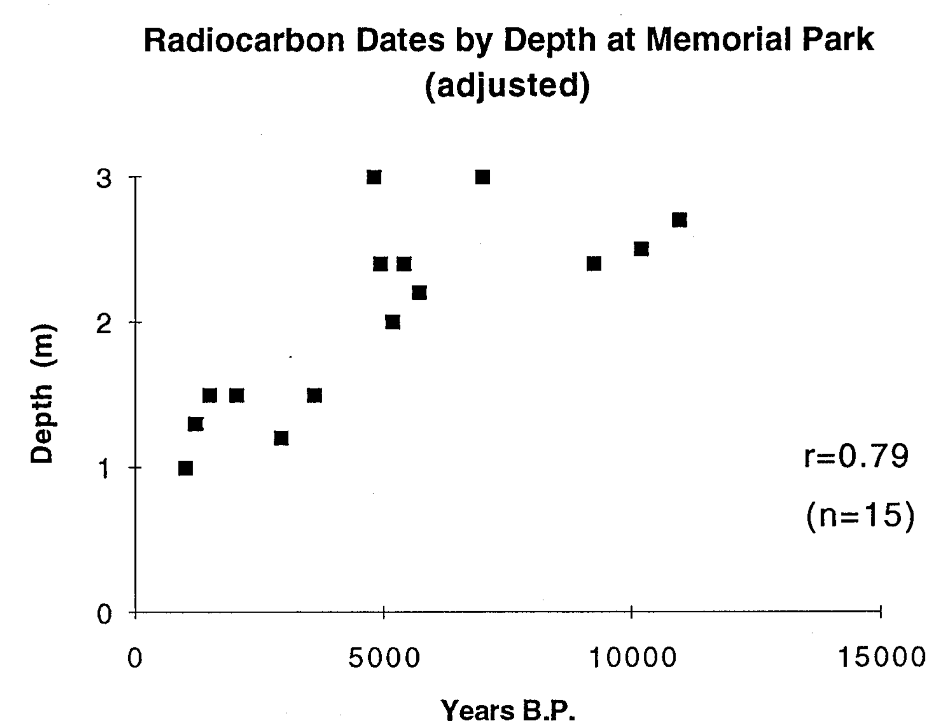


Figure 5-6b

Figure 5-6. Correlation plots of Radiocarbon Dates by Depth over the course of prehistoric time. The next section presents a comprehensive reconstruction of the dynamic occupational environments over the past 12,000 years.

CHAPTER 6: LANDSCAPE CHANGE AND THE GEOARCHEOLOGY OF MEMORIAL PARK

The field and analysis components of the deep testing effort underscored the variability in the subsurface terrain at Memorial Park. A variety of soil-sediment "packages" indicated that the near level contemporary terrain is underlain by a series of buried surfaces whose contours diverge significantly from those of the present. Moreover, the variability is pronounced across certain segments of the site landscape and is more subtle in others.

The present section attempts to integrate these observations into a model of Holocene landscape change. More significantly, it links the patterning in the buried landscape record with the differential occupation of particular surfaces through time. The non-uniform utilization of the Memorial Park site reflects systematic selection of elevated and well drained segments of the landscape at given points in time. By "mapping on" prehistoric distribution with buried landscape segments, soils, and surfaces it is possible to identify both changes in floodplain and environmental history as well as isolate those components of the landscape that were most attractive to prehistoric peoples and which are most likely to contain preserved records of their activities.

This section synthesized the field observations in several stages. First, we isolate broad trends in subsurface stratigraphy based on the identification of four prominent depositional "belts"; the belts conform to sedimentation gradients that functioned across the floodplain and terrace. Next, we examine subsurface soils, surfaces, and alluvial facies distributions by linking the profiles across three discrete transects that encompass the major segments of the T-1 landform. Variability in sedimentation rates is indexed by the battery of radiocarbon dates assembled for the study area. In this way it is possible to isolate those time frames during which the most dynamic floodplain environments were active. The fluvial changes are then integrated with the soil chronology as well as regional and more broadly based paradigms of Holocene climatic change.

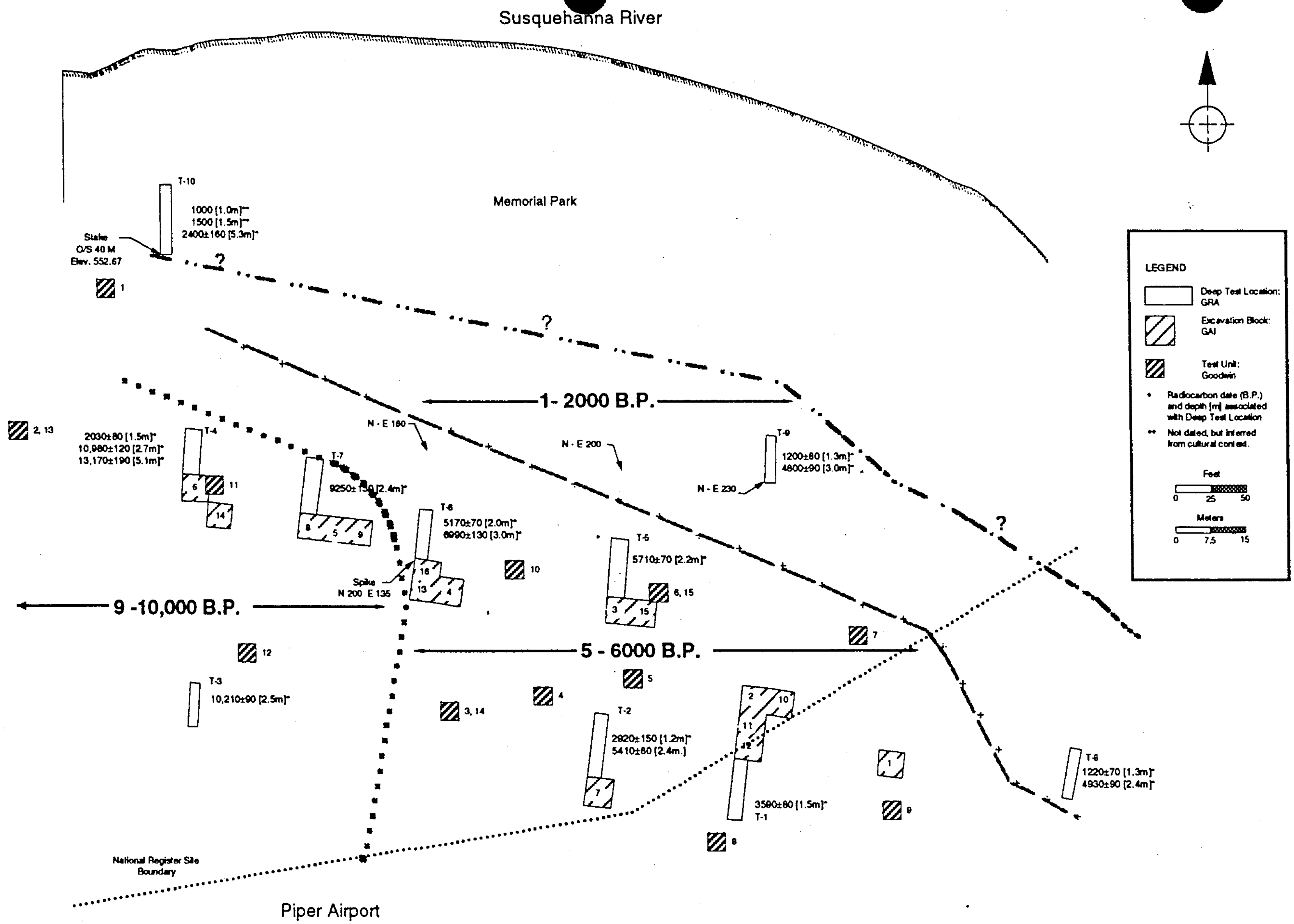
Finally, we plot the distributions of the buried surfaces and archeological loci to chart synchronic and diachronic patterning across the site.

Isolation of Principal Depositional "Belts"

Figure 6-1 is a subsurface isobar plot of dated buried surfaces across the T-1 landform to 2.5 m. The depth represents the average depth of excavation for the ten trenches. As shown, three separate depositional belts may be discerned, structured by age. The basal age of the deposits decrease systematically along a southwest-northeast gradient. In the southwest segment of the site, the oldest deposits date to 9,000-10,000 years B.P., the second belt's lowermost deposits are 5,000-6,000 years old, and the levee and near bank edge alluvium dates to Late Holocene times (1,000-2,000 B.P.) at 2.5 m deep.

The southwest portion of the site is the only segment where the Pleistocene/Holocene interface were identified. It was encountered at depths between 3-5 meters in the form of imbricated gravels and coarse, lenticular sands. Significantly only minimal Middle Holocene soils or alluvium are contained within these sequences. Related archeological deposits and Cambic profiles begin to appear only as late as 2,000 B.P. The absence of preceding Archaic deposits and occupation loci may signify sustained erosion of the surfaces during the Middle Holocene. Over much of the prehistoric period this terrain was the highest and best drained component of the landscape. The channel gravels preserved to depth at this solitary location offered the earliest indications that by 13,000-11,000 B.P. the West Branch began to migrate to the northeast.

The second belt dates to between 5,000-6,000 B.P. (Figure 6-1) and preserves repetitive fining upward and then coarsening upward sequences. These are also the optimal locations for isolating Middle/Late Archaic features and soils (Hart 1993). Depositional suites suggest lateral accretion that is a signal indicator for a migrating stream regime. Additional geomorphic data in support of this pattern is the sandier loam composition of the parent alluvium in almost all deep test exposures in this



Georcheology Research Associates **5912 Spencer Avenue** **Riverdale, N.Y. 10471** (718) 601-3861 Phone (718) 601-3864 Fax	DRAWING TITLE Figure 6-1. Isobar Plot: Age of Subsurface Deposits 2.5 m (base of Deep tests)		
	PROJECT Lock Haven, PA	DRAWN BY drb	SCALE na
		DATE 11/22/93	REVISION 11/22/93

belt. The dates bracketing a lateral facies change indicated that during the Middle Holocene, the West Branch was actively migrating to the northeast and building up broader, sandier floodplains to traverse. The susceptibility of such substrate to erode is consistent with the general paucity and poor preservation of Early and Middle Archaic sites along the Susquehanna and other major trunk streams of the Eastern Woodlands.

There are no datable sediments between 4,800-3,600 B.P., suggesting an interval of extreme channel adjustment and migration. This may have been a period of complex channeling and regional realignment of hydrographic systems. However, by the time of the Late Archaic/Woodland transition, the homogeneous T-1 landscape had effectively assumed its contemporary morphology. This is the landscape that was actively settled by later prehistoric groups, including the Clemson Island peoples. Significantly, all of the subsurface tests indicate a deep Clemson Island/Late Woodland component that was preserved in fragile context. The top of an apparent midden was truncated by the bottom of historic plow zone deposits. For this reason, the integrity of the component was severely compromised in places. Its size and extent cannot be overstated since it left the most prominent anthropogenic signatures in the entire stratigraphic record.

The curvilinear distribution of the belts (Figure 6-1) underscores the trend to channel migration to the northeast, and <u>away</u> from the oldest preserved sediments in the southwestern portion of the site ("Belt 1"). This is reflected in the zonation of soils of decreasing antiquity to the northeast. Accordingly, Archaic period soils are preserved in "Belt 1". These were classified as Fragipans and dated to between c. 4,000-5,000 B.P. in the Phase III study ("Soil 4, Bx or Btx horizons"; Cremeens 1993: 112). On chronological grounds, Cremeens based this designation on the model of Bilzi & Ciolkosz (1977:126) that argues for a minimal range of 2,000-12,000 years for the development of "fragipan like features" in Pennsylvania alluvium. Soils of this age were not unequivocally identified in Belt 1 by the present work, although Argillic horizons were identified here and to the northeast ("Belt 2; 5,000-6,000 B.P.") and these appear to correlate with this soil. "Belt 2" preserves typically thinner Bt horizons and deeper Ab horizons suggestive of sustained humic covers consistent with near channel position at a time when flooding was not excessive and overbanking was the dominant depositional mode. Finally, "Belt 3" is covered by soils and sediments that are fully 4,000 years younger than those of the southern and western portions of the landscape. They provide indications that a major cut and fill cycle was initiated in Late Holocene times, as a new floodplain was constructed (T-0) and was inset against the older T-1 landform.

Assessment of Composite Stratigraphy

One of the key elements in the evolution of the terrace landscape at Memorial Park was its location at the juncture of Great Island at a valley location where the West Branch itself is a misfit stream; it occupies a valley that is too large for the channel. The breadth of the Valley has in the past and continues to sustain the West Branch as well as Bald Eagle Creek. Great Island itself records numerous meander scars indicative of the sinuosity of antecedent streams in the flood belt.

Sinuosity and a migrating channel pattern should therefore be considered key components in the assessment of the history of channel flow and aggradation. It follows that evidence for such behavior is preserved in the sediment record as well as in the surface morphology of the channel and valley. If the connection between channel migrations and sedimentation can be identified and dated it should also be possible to isolate periods of vertical accretion and overbanking, thereby defining changing environmental conditions and climatic trends. These, in turn, are invaluable in reconstructing the prehistoric ecology of the area. The first objective in the composite stratigraphic analysis was to localize threshold levels in stream history through recognition of facies changes documenting the passage from a migrating to an overbank stream. Transition phases a Prehistoric occupations are typically associated with these transitions and the stable environments of the intervening soils.

Figure 6-2 illustrates three transects crossing the Memorial Park site along axes that coincide with the "depositional belts" identified earlier. The ages of the belts offered broad chronostratigraphic controls for the sequences. Transect A-A' (Figure 6-3)

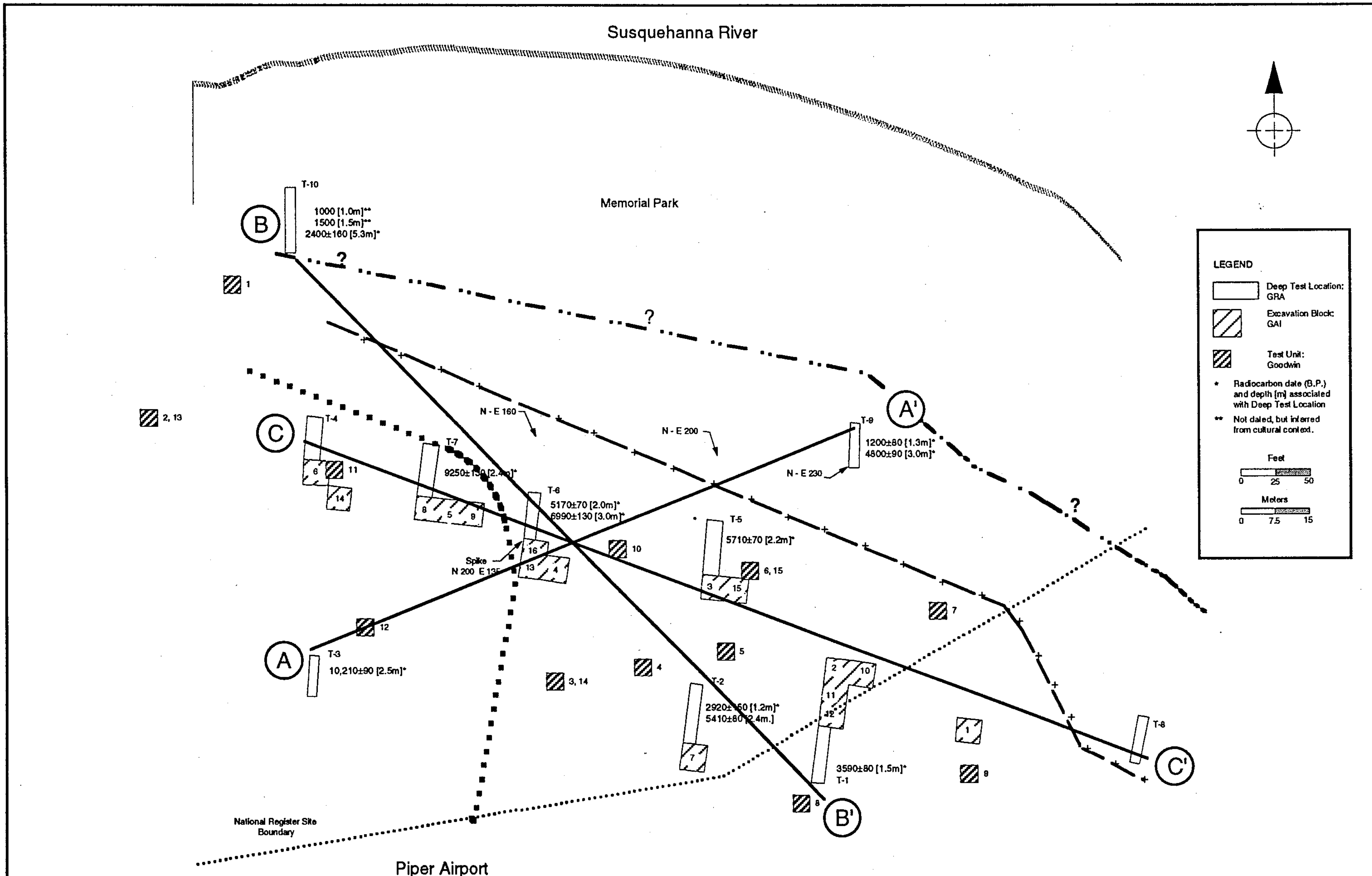


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Figure 6-2. Geoarcheological Transects: Memorial Park		
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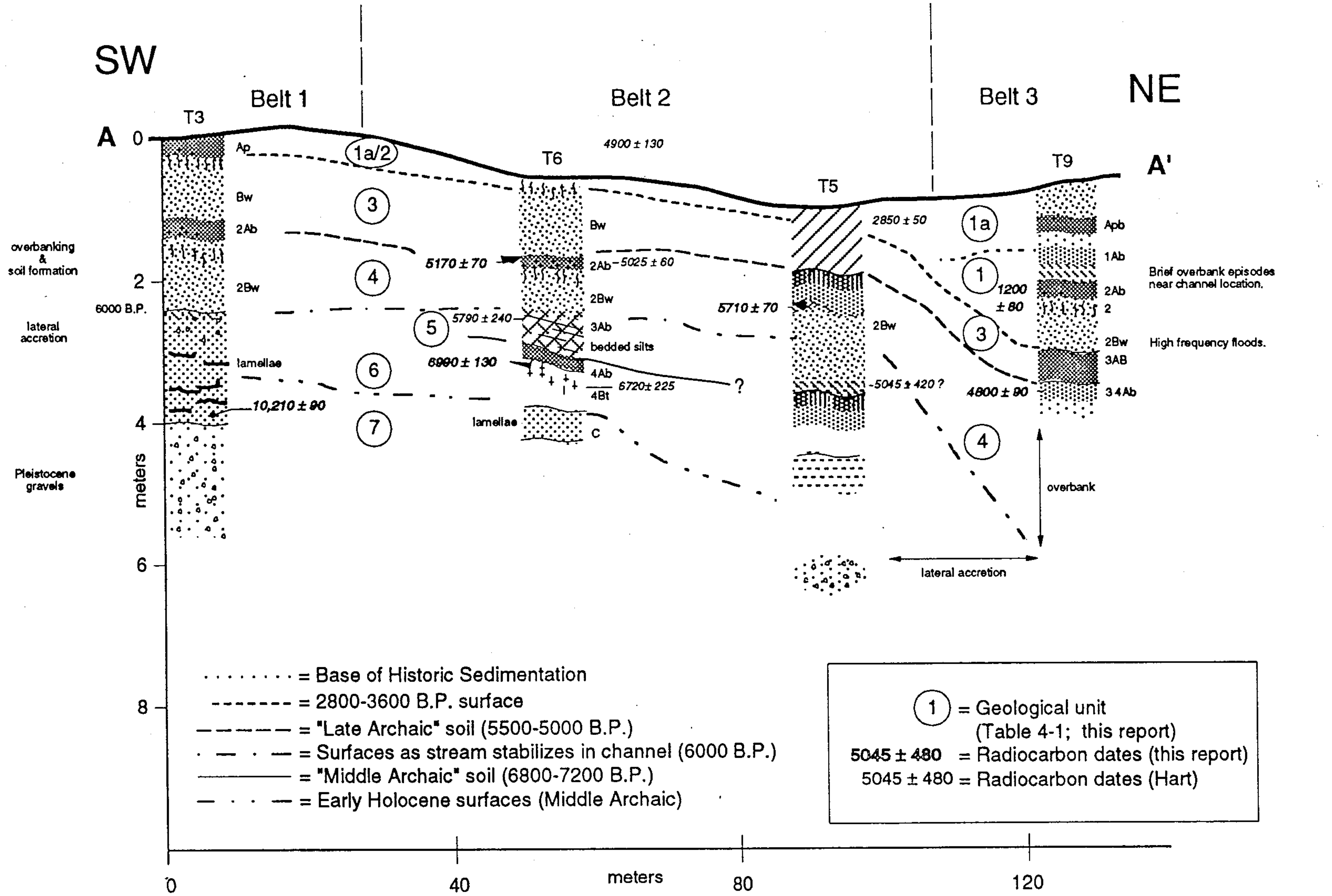

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Figure 6-3. Composite Profile A-A'

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extends northeast from the oldest Pleistocene landforms to the margins of the recent levee. It is transverse to the curvilinear configuration of the belts and therefore cross cuts the site stratigraphy from the oldest to the youngest buried landscapes (Belts 1-3). In contrast, Transect B-B′ (Figure 6-4) begins at the youngest landscape and runs parallel with the grain of the intermediate belt (Belt 2). It was designed to monitor the depositional variability within a confined time range and across across a single belt. Transect C-C′ (Figure 6-5) traverses the interior landscapes of the site, removed from the active floodbelt parallel to streamflow. While crossing all the belts, it gauges the potential differences between past and present patterns of deposition along the contemporary axis of sedimentation. In assembling the data for the transect, careful attention was paid to soil development and depositional breaks. Finally, it should be noted that the transects were deliberately designed to merge at T-6, since this location offsets the archeologically richest portion of the site.

The single most important index of change was, of course, time. An effort was therefore made to incorporate all contextually meaningful radiometric dates from the Phase III report (Hart 1993: Table 47). The determinations, however, were never integrated into the sequences. Accordingly, the master pedological sections were examined (Cremeens 1993: Figures A-1 to A-16) and the provenienced dates from Table 47 were overlaid onto the appropriate levels in the sections. The pedostratigraphies of Cremeens were referenced in a general way to insure that the present stratigraphic designations could incorporate the previous dates in meaningful fashion. When possible, dates were linked to similarly described strata. In some cases, specimens could be cross referenced in sections by measurements from field datum points. Some dates may not be assigned to appropriate strata, but this is generally the exception. The correspondence between dates across most strata tends to reinforce the reliability of the determinations from both studies. Still, dates from each study are keyed separately (see Figures 6-2 to 6-5). Stratigraphic units follow the nomenclature and designations established in Chapter 4 (see Table 4-1) where the baseline stratum is the geological unit. All seven (7) principal units are preserved in the three sequences, although only two exposures preserved all strata (T-3 and T-4).

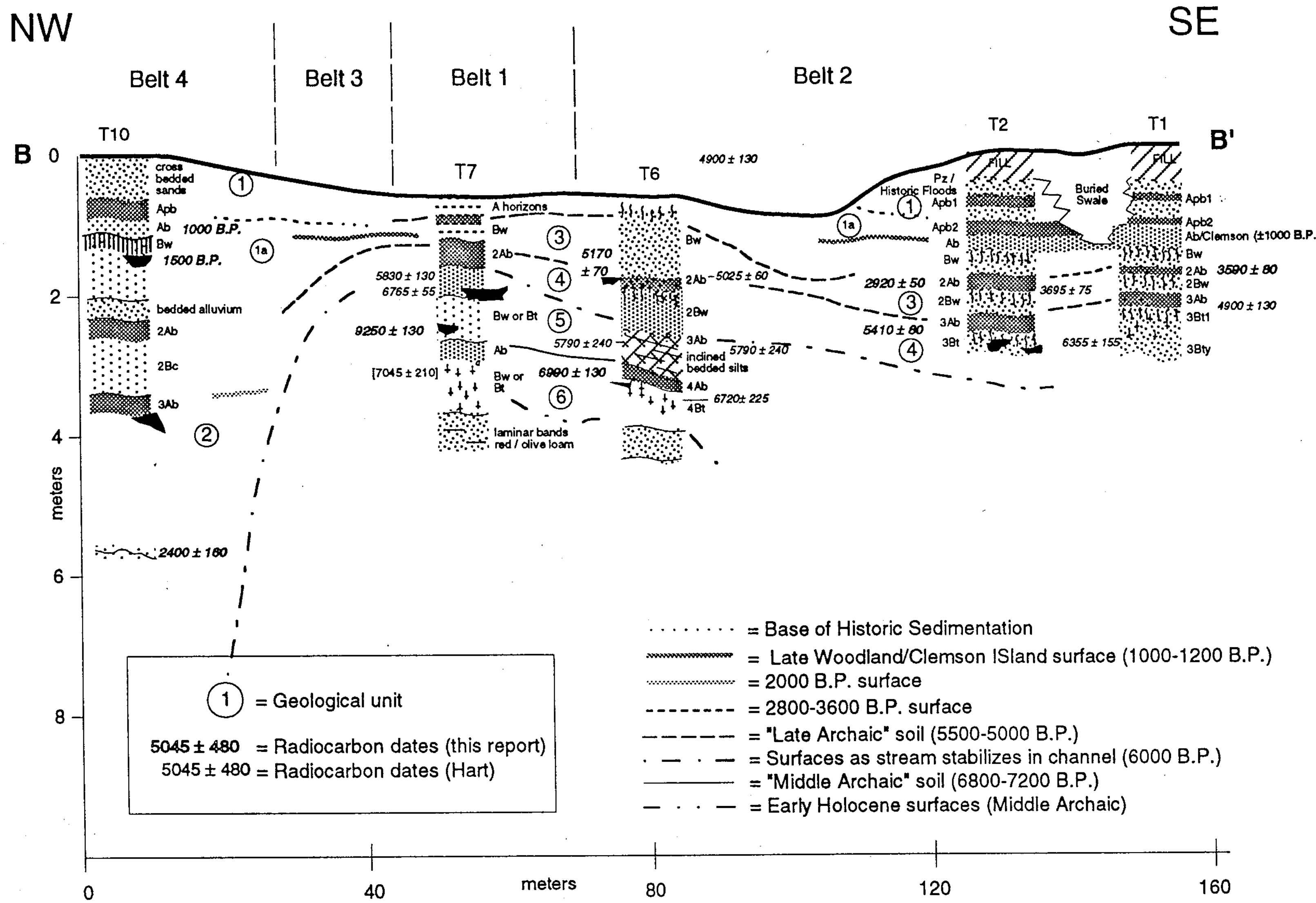

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Figure 6-4. Composite Profile B-B'

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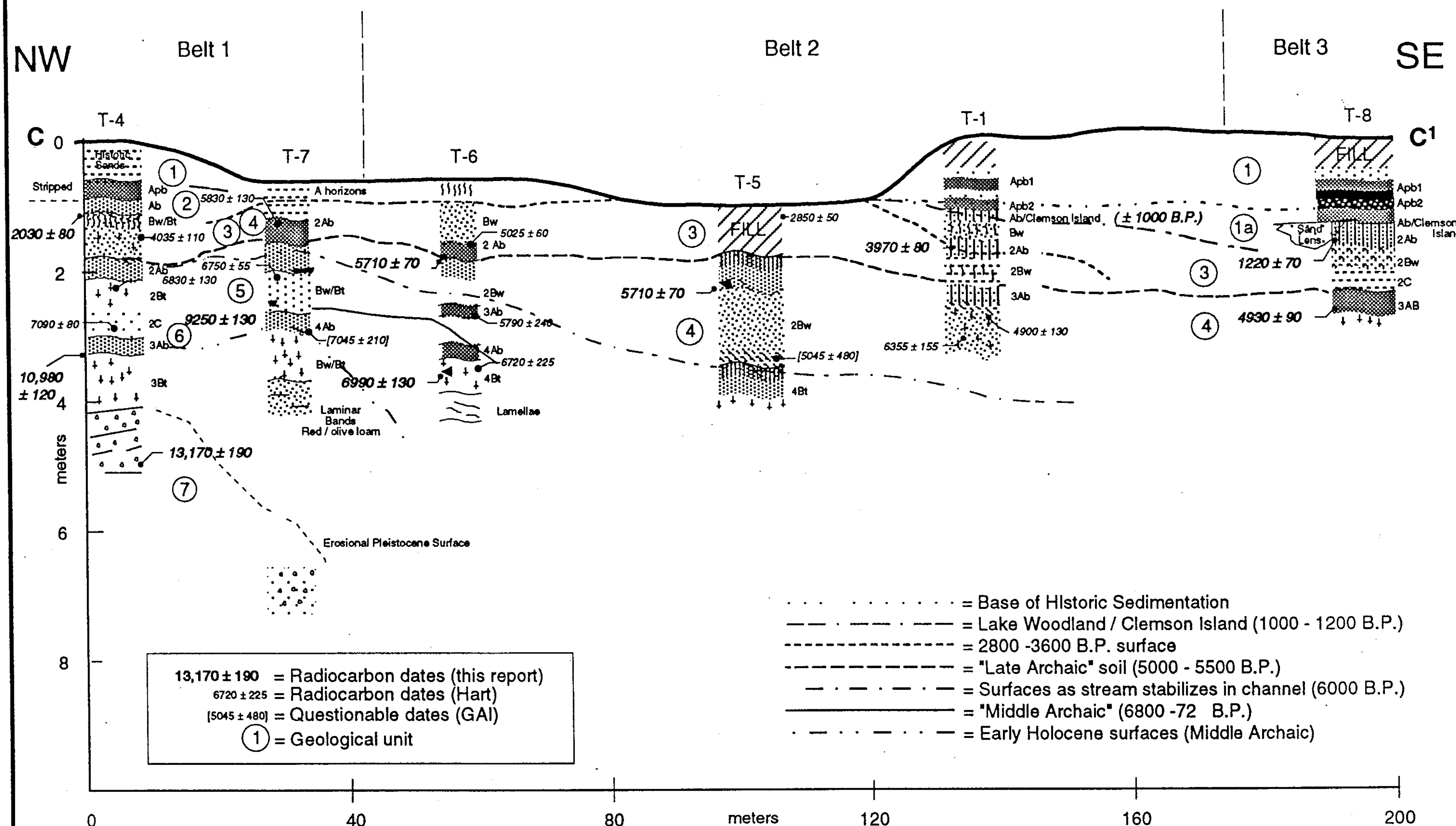

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Transect A-A′ (Figure 6-3) is perhaps the most informative section for general landscape evolution, since it spans the oldest through youngest landforms over a limited distance. It registers six discrete surfaces beginning with the Pleistocene-Holocene transition in T-4. The oldest deposits are typically identified between 4-5 m and can be traced across Belts 1 and 2. As shown, the coarsest Pleistocene gravels are displaced by lateral accretion deposits (fining upward sequences) that can also be tracked between the same belts; however, at T-5 the depths at which these deposits are encountered falls off precipitously. As shown, while units 7, 6, and 5 feature sub-horizontal dispositions across the site, they do not extend to the younger Belt 3.

Moreover, the more recent units--from the base of 4 upward (6,000 B.P.)--are identified in Belt 3, but at depths fully 2 m below those on the older (southwest) portion of the site. These topo-stratigraphic relations are accompanied by a discrete facies change, from a coarse base, fining upward, coarse top sequence, to a poorly sorted, finer grained (silt and clay dominant) overbank deposition. As shown in Figure 6-3 at the approximate depth of unit 4 and east of T-5, the surfaces begin to aggrade or build up and lateral migration was halted (see arrows at unit 4 base). Concurrently two levels evolved for a new terrace/floodplain environment. The subsurface relations of units 1-4 are nearly identical, representing incremental overbanking. Two discrete buried levels are associated with each unit: the concavities underlying Belt 3 that represent the position of the former floodplain (T-0) and the raised surfaces of the first terrace (T-1) that overlook the T-0 and the then extant channel which also sustained the primary archeological loci. As shown, the highest surfaces were constructed by unit 3 times, or approximately 3,000 B.P. These are the most stable surfaces on the site today (at T-3 and T-6).

In contrast to the overbanking regimes dominant between 6,000-3,000 B.P., lower surfaces are nearly sub-horizontal (between 10,000-6,000 B.P.). Coarser gravelly sand matrices in the lower strata may be indicative of a braiding stream regime while the upward fining facies are more classic evidence for lateral migration. In neither case is there evidence for incision or cutting and filling, but simply extensive traverses of a broad floodplain. Floodplains were broadly accreting.

A similar pattern is evident after 3,000 B.P. A new cycle of cutting and filling is initiated as indicated by the rapid overbanking and weak soil formation in the profiles at T-9. Limited pedogenesis is a function of the recent age of the solum (1,500-1,000 B.P.) and only a moderately developed Bw (Cambic) profile has formed. A new floodplain (T-0) emerged to the east, in response to ongoing migration of the channel and, not surprisingly, Late Woodland archeological deposits are contained in the matrix of this distal segment of the landscape.

Transect B-B′ (Figure 6-4) illustrates a more heterogeneous stratigraphy, with the oldest landform elements (Belt 1: T-7) flanked by the youngest to the northwest and the intermediate to the southeast (Belt 4 and Belt 2). Significantly, the older terrain (Belt 1) preserves the most complete record of strata. Typically, the individual units are thin due to limited deposition on the highest and driest site terrain. Accordingly, the densest archeological levels are preserved here in almost all units. The most dominant unit here, as elsewhere across the site is the "Late Archaic" soil, which is nearly level and offsets the most extensive and stabilized surface across the landform. Older, lateral accretion deposits capped by Argillic soil profiles mark the base of the sequence. To the southeast, the equivalent upper surfaces are fully 2,000 years younger, and are represented by very weakly weathered sola (Entisols) that are thin and capped by successions of "A-C′ horizons. To the west, the former levee (T-10) preserved the most anomalous stratigraphy registered anywhere across the site. Here a date of 2,400±160 B.P. was obtained at a depth of 5.5 m. The depth of sedimentation reflects considerable aggradation at the channel margins since the last cycle of incision ended--between 3,000-2,000 B.P.--and overbanking was initiated, apparently at an accelerated rate.

Transect C-C′ (Figure 6-5) runs parallel to the present channel flow axis. Not surprisingly, subsurfaces are sub-horizontal for all units above unit 6, again offsetting the period of near uniform overbanking around 6,000 B.P. The oldest deposits are represented by the Pleistocene gravels, here dated to 13,170±190 B.P. Subsurface contours for the gravels are pronounced and reflect the high discharge environments of the late glacial periods. When the lateral accretion regime was initiated, gradients leveled, such that by 5,000 B.P. the gradients along this transect were analogous to those of the present thalweg. As shown in the exposures of Belts 1- 2 at near surface elevations, deposits as high as .2 m below surface date to about 3,000 B.P., again confirming both the stability and antiquity of the southwestern portion of the landscape. These are the most compressed stratigraphies registered across the project area.

Sedimentation Rates

To gain more precise insights on the timing and scale of floodplain dynamics, sedimentation rates were calculated for the best dated landform segments. The utility of the method has been explored by a number of researchers (Anderson and Schuldenrein 1983; Graff 1977; Hall and Lintz 1983). Most recently, Ferring (1986) has summarized prevailing interpretations and concluded that carefully designed sedimentation rate studies at floodplain sites provide information on past climatic and hydrographic systems as well as site preservation conditions.

For the Memorial Park site, we attempted to check the variability between the four landscape "belts" by sampling dated thicknesses of deposit in each. Data were collected from two sources: first, from deep trenches of the present investigations, and, second, from block profiles of the Phase III investigations (Hart 1993). For each exposure a minimum of two radiocarbon samples (soils or charcoal) separated by a measured vertical accumulation was a minimal requirement for sampling; most exposures selected contained three separated dates as well as the uppermost surface that served as an additional temporal control (i.e., baseline date: 0 B.P.). For each set of dates the thickness of sediment was divided by the difference between the bracketing ages to derive the mean sedimentation rate/year. This number was multiplied by 100 to conform to standard presentation formats (cm/100 years).

Figure 6-6 presents a distribution of 33 sedimentation rate calculations for the four "belts" spanning the site. The graph illustrates that sedimentation rates were highest for the Early Holocene, even though very few samples represent this time frame. After 6,500 B.P. sedimentation rate variability becomes progressively more subdued, until 2,500 B.P. when there is a uniformly moderate rate of 4 cm/100 years. As noted

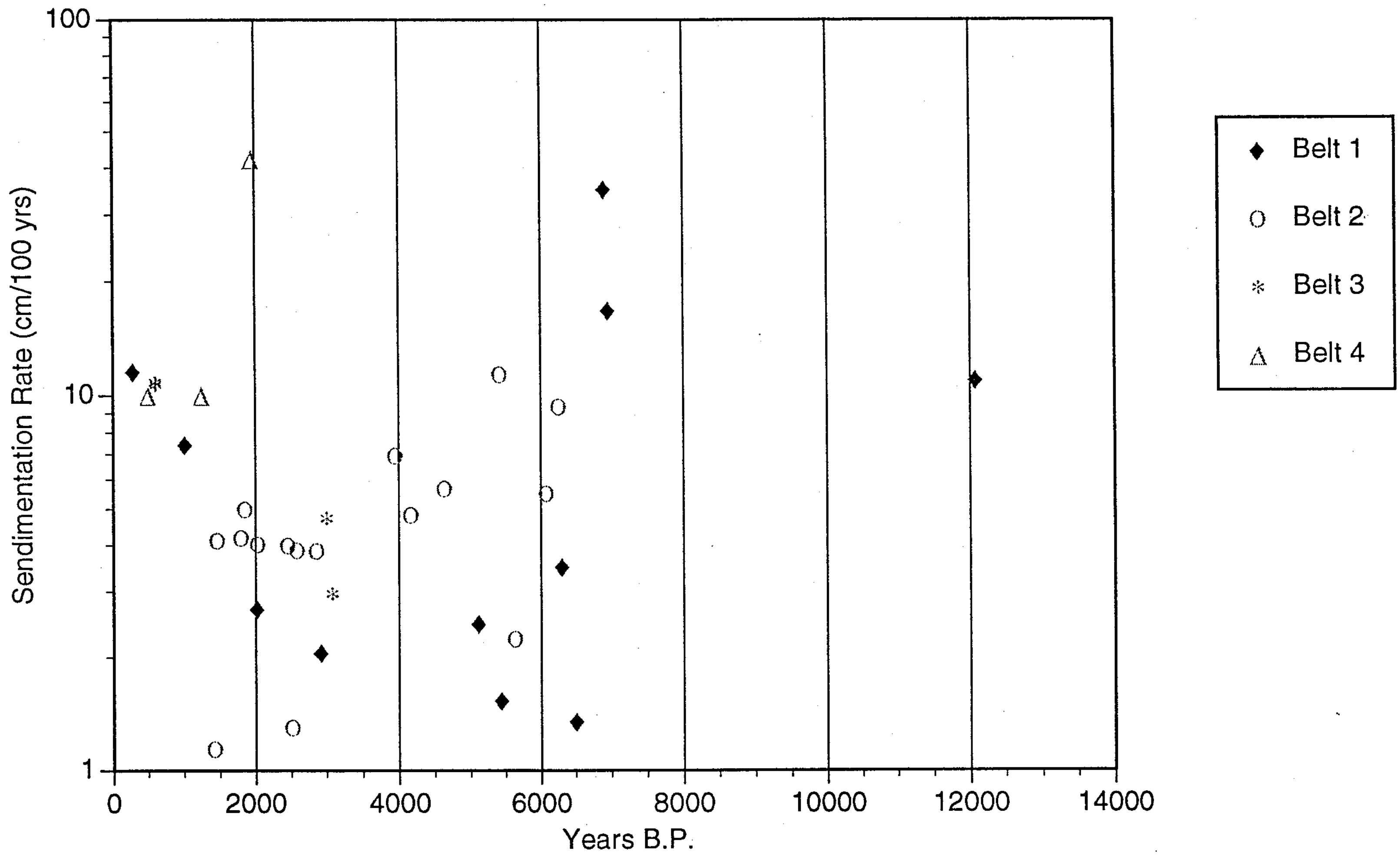


Figure 6-6: Sedimentation Rates at Memorial Park

earlier, this is a period when incision of the contemporary floodplain surfaces gave way to a new cycle of sustained aggradation. Apparently, it also marks a phase of general landscape stability.

A reduction in sedimentation rates on the order of 2-3 times took place during the middle Holocene, based on the average of all mean sedimentation rates plotted by 1000 year increments. Significantly, this is about the time that slow alluviation gave way to lateral channel migration and modest incision in the Eastern Woodlands (Knox 1983). Effectively, there is a correlation between the reduced base level signified by channel migration and the plunge in sedimentation rates from 11.8 to 4.4 (reduction of 2.68 times) according to Figure 6-6. The more gradual diminution between 6,500 to 2,500 B.P. is clear and confirms general stratigraphic observations that lateral accretion was being displaced by overbanking as the dominant accretionary floodplain process (see Figure 6-3). The regional models suggest that such stability occurs slightly later, by 4,000 B.P. (Knox 1983). The rate curve illustrates an appreciable reduction in the range of sedimentation at this time. The curve shows a second drop in alluviation rates from 5 cm/100 yrs. to 3.2 between 3,500-2,500 B.P., again attesting to the resumption in overbanking activities after 3,000 B.P. It climbs drastically after 2,500 B.P. when active channel migration and cutting and filling resume on a considerably larger scale. Thus the regional fluvial sedimentation model is largely supported by the present data and field stratigraphic observations, with one critical exception: overbanking was probably initiated in the Susquehanna by 6,000 B.P. rather than the accepted date of 4,000 B.P.

Correlations between the sediment rate data and the discrete "belts" produces the following observations:

1. Belt 1, with the oldest landforms has the broadest variability for both sedimentation rates and the age of sediments. Both the lowest and highest sedimentation rates are represented in this belt. The oldest dates (12,000-7000 B.P.) correspond to sedimentation rates between 11-35 cm/100 yrs. Significantly, immediately after this, the rates plummet for the range 6500-2000 B.P. (1.3-3.5 cm/100 yrs). Subsequently rates surge again between 1000 B.P. to present (7.4-11.5 cm/100 yrs.).

2. Belt 2 has the largest number of dates generally. They also feature a very confined date/sedimentation range distribution. There are two modes to this distribution. First, between 3,000-1,500 B.P. sedimentation rates are quite narrow, between 3.8-4.1 cm/100 years. There are two even lower sedimentation rates (between 1-2 cm/100 years) here as well. A second mode is between 4.8-11.2 and date ranges are 4,000-6,500 B.P. No sediments from Belt 2 are younger than 1,500 B.P.

3. Belt 3 is represented by only four dates. These may represent two groups. One is an association between 3-5 cm/100 years around 3,000 B.P. Here there is also a surge in sedimentation after 600 B.P. This would identify an area that has been especially flood prone over the past 600 years.

4. Belt 4 is represented by 3 dates. The distribution displays high sedimentation rates over the past 2,000 years and is similar to that of Belt 3.

Modeling a "Genetic Stratigraphy" for Memorial Park

Unlike the previous studies (Neuman 1989; Cremeens 1993), this study stresses the depositional variability responsible for the various solas present at the site. Special emphasis was placed on defining the effects which changing Holocene climate had, both on the fluvial regime of the Susquehanna River, and the depositional sequences in which the stacked solas at the site formed.

The following discussion attempts to define the Memorial Park stratigraphic sequence within a genetic model proposed for the central and upper Susquehanna River drainage basin (Vento and Rollins 1989; Vento et al., 1992).

Southwestern Site Segment (Belt 1): As discussed earlier, the southwestern portion of the site contains the oldest remnant landforms. The basal deposits in each of these trenches are coarse sands and gravels emplaced during periglacial/late glacial times (11,000 - 14,000 yrs. B.P.). A single radiocarbon date of 13,170 ± 190 yrs. B.P. from a sandy loam, olive gray, gleyed organic-rich, channel fill deposit above the basal gravels in Trench 4 (Figure 6-5) documents a minimum age for abandonment of this former channel segment. In the same trench, another radiocarbon date of

10,980 ± 120 yrs. B.P. from the 2Ab horizon documents a period of relative flood plain stability which favored A-horizon development. The pronounced facies change and stratigraphic transition underscores that the change from a braided channel to a meandering fluvial regime took place sometime between 11,000 and 13,000 yrs. B.P.. This was in response to more mesic climatic conditions of the early Holocene. Prior to 11,000 yrs. B.P., the effects of the abating ice sheet and greater effective precipitation precluded active vertical accretion or aggradation of the flood plain. A date of 10,210 ± 90 yrs. B.P. from a Cambic B-horizon (2Bw) just above the basal gravels (lateral accretion) in Trench 3 further supports the timing of the transition between 11,000 and 13,000 yrs. B.P.

Following establishment of a meandering channel habit, the alluvial sequence or soil stratigraphy in Trenches 3, 4 and 7 (Figure 6-5) is typical of a levee or bank edge channel segment. During this time, the active channel would have been immediately to the north and east of Trenches 3, 4, and 7. Trenches 1, 2, 5, 6, 8, 9, and 10 occupy the footprint of the then active channel (Figures 6-4, 6-5). The three Holocene-age buried Ab and Bt/Bw horizons in Trenches 4 and 7 are correlative and correspond to other dated solas within the Susquehanna River drainage basin (Vento, Rollins, and Stewart et al., 1992). The basal 3Ab horizon in both Trenches 4 and 7 documents a period of relative flood plain stability during warmer and moist conditions of the early Boreal climatic phase. This interval of floodplain stability was terminated at ca. 9,000 yrs. B.P. by a period of increased overbank deposition and active lateral channel migration during the warm-dry late Boreal climatic phase. Knox (1983) notes that during the continued ablation of the Wisconsin ice sheet, warm/dry air masses from the Pacific became increasingly predominant between 9,300 to 7,700 yrs. B.P. Davis (1983) states that by 9,000 yrs. B.P., the climate was warmer than it is today. Davis (1983) adds that the expansion of white pine at this time in both lowland and upland settings is an excellent indicator of warmer climatic conditions. Furthermore, Kutzbach (1983) states that based upon the results of orbital variation models, the period 9,000 yrs. B.P. received 7% greater solar radiation than it does today. A 9,250 ± 130 yrs. B.P. date from the base of a 2Bwb/Bt horizon in Trench 7 (Figure 6-3) which immediately overlies the 3Ab horizon documents a period of more active vertical accretion in response to warmer-dryer climatic conditions. Absence of the 3Ab horizon in Trench 3 was due to its removal by a flood event (C2) which is not present in either Trenches 4 or 7. The fact that Trench 3 was positioned in a more proximal or bank-edge position may explain this occurrence.

The overlying 2Ab horizon in Trenches 4 and 7 (Figure 6-5) again documents a period of relative flood plain stability which favored A-horizon development. Based upon radiocarbon dates and temporally diagnostic artifacts, this horizon dates to ca. 3,000 yrs. B.P. (Sub-Atlantic climatic phase). It is interesting to note that there are less than 1 m of overbank deposits between the 3 Ab and 2Ab horizons in Trenches 4 and 7, yet this soil package represents a time interval of over 7,000 years. One plausible explanation for this occurrence is that as the channel began to migrate to the east and north, overbanking events were less likely to inundate and breach this higher, remnant levee landform. Any sediment contribution supplied to this landform would have been desegregated and mobilized into the developing sola.

The period 3,200 yrs. B.P. to 1,800 yrs. B.P. was again one of relative floodplain stability during the warm and moist climatic conditions of the Sub-Atlantic climatic phase. This period of A-horizon development was then terminated by a new cycle of more active vertical accretion associated with the cold-wet Scandic climatic phase (circa. 1,800 yrs. B.P. - 1,100 yrs. B.P.). More effective precipitation during this time favored overbanking and the development of the Bwb horizon in Trenches 3 and 4 (Figure 6-3). This horizon is missing in Trench 7 due to its removal during the Phase III site mitigation. This relatively lengthy cycle of overbanking was then interrupted by relative floodplain stability during the warm-moist Neo-Atlantic climatic phase (1,100 yrs. B.P. - 750 yrs. B.P.). This episode of stability and A-horizon development is represented across the site by the uppermost buried A-horizon containing the Clemson Island midden. Termination of this A-horizon (Bw horizon in Trench 3) was in response to colder-wetter climatic conditions of the Pacific or Little Ice Age climatic phase (beginning ca. 700 yrs. B.P.). The overlying stacked C and Ap/Apb horizons across the site document the effects of historic deforestation. Over the last 200 years, deforestation has allowed for larger floods in response to higher sediment yields and greater amounts of surface runoff.

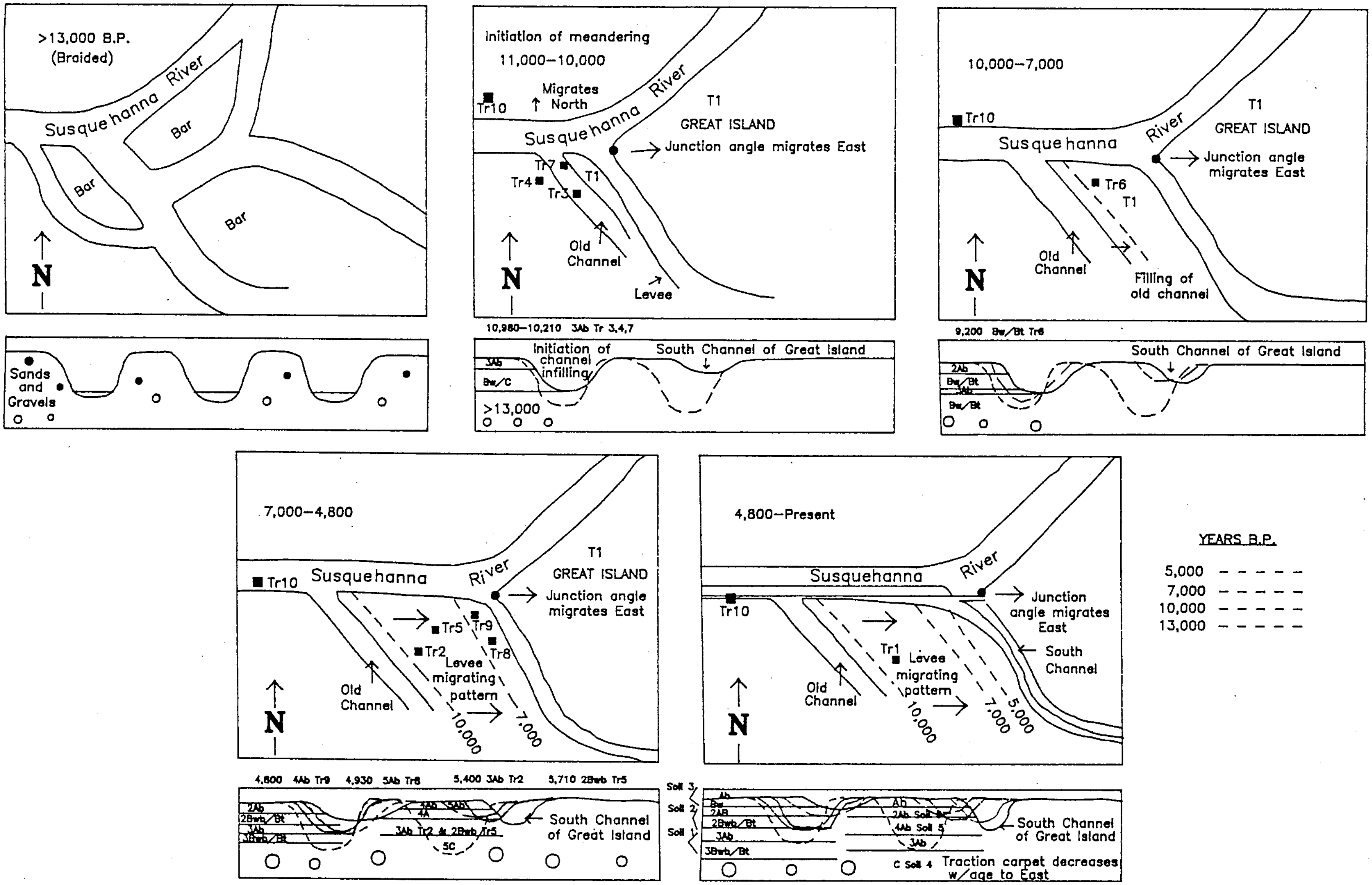
Central and Eastern Site Segment (Belts 2, 3): Trenches 1, 2, 5, 6, 8, and 9 ("Belts 2, 3"; Figures 6-4, 6-5) comprise the central and eastern portions of the Memorial Park Site. None of the radiocarbon date horizons from these trenches predate 7,000 B.P. As noted above, this is due to the fact that the active channel(s) was located immediately to the east and north of Trenches 3, 4, and 7 (Figure 6-1). Beginning approximately 10,000 yrs. B.P. and in response to its new meandering habit, the West Branch began to adjust and shift its junction angle to the east and north, as shown in Figure 6-7. This period of slow active lateral channel reached its near present position approximately 5,000 to 6,000 years ago. In roughly 4,000 years the channel has migrated some 70 m (230 ft) to the north and 200 m (660 ft) to the east. Proceeding west to east (Trench 6 to Trench 9; Figure 6-3) across the site, the basal age for the artifact-bearing vertical accretionary deposits gets younger and younger. In Trench 6, the 4Ab horizon yielded a date of 6,990 ± 130 years while the lowermost Ab horizon (4Ab) in Trench 9 yielded a date of 4,800 ± 90 years B.P. (Figure 6-3). Both horizons lie within 50 cm of basal lateral accretionary deposits (e.g. , channel lag). The period of time allowed for the river to migrate the 60 m (220 ft) difference between Trench 6 and Trench 9 is roughly 2,200 years.

Within the eastern site segment, the 3 m to 4 m thick package of Holocene age vertical accretion deposits contain between four and five buried, stacked soil sola. All of these sola postdate the Boreal and early Atlantic climatic phases (circa. >10,000 to 8,000 yrs. B.P.). The 4Ab horizon in Trench 6 (Figure 6-3) which yielded a radiocarbon date of 6,990 ± 130 years B.P. does not appear to be directly correlative with other dated, buried horizons in either the eastern or western portions of the site, although it is possibly linked to Middle Archaic archeological horizons (Hart 1993). Unlike the 4Ab horizon in Trench 6, the 3Ab horizon in Trenches 1 and 2 and the Bw horizon in Trench 5 are temporally equivalent (Figures 6-4, 6-5). The buried A-horizon which should be associated with the Bw horizon in Trench 5 was removed by the earlier Phase III excavations. Based upon a projection of the stratigraphy, it is possible that the missing 2Ab horizon in Trench 5 is correlative with the 3Ab horizon in Trenches 1, 2, and 6 (Figure 6-4). Again, both the 4Ab horizon in Trench 6 and the 3Ab and 2Ab horizons in Trenches 1, 2, 6, and 5, respectively, represent durations of relative floodplain stability for several hundred years during the warm and moist Middle Atlantic climatic phase. Shortly after 5,400 years B.P., several minor overbanking events were able to terminate A-horizon development. This sediment/soil package today is represented by the 2Bw horizon in Trenches 1, 2, and 6 and the Bw horizon in Trench 5 (Figures 6-4, 6-5).

The following phase of A-horizon development can be found in Trenches 8 and 9 (Figures 6-3, 6-5). The 5AB horizon from Trench 8 and the 4Ab horizon from Trench 9 have yielded radiocarbon dates of 4,930 ± 90 yrs. B.P. and 4,800 ± 90 yrs. B.P. respectively. It is possible that these horizons are time equivalent to the 3Ab horizons from Trenches 1, 2, and 6 (Figure 6-4) and that the older humic acids dated from these more western trenches have allowed for the noted time differences. A second possibility might be that the more proximal or bank-edge position of Trenches 8 and 9 had allowed for the formation this younger more cryptic paleosol.

It is interesting to note that there are no datable sediments between 4,800 yrs. B.P. and 3,600 yrs. B.P. This gap suggests an interval of extreme channel adjustment, migration and avulsion along the West Branch channel. The period corresponds with the warm-dry Sub-Boreal climatic phase (4,500 yrs. B.P. to 3,200 yrs. B.P.). During this time, the channel would have promoted active lateral migration and overbanking in response to less effective precipitation and increased sediment supply from vegetation changes (Vento and Rollins 1989). It is during this middle Holocene period (Atlantic climatic phase) that large cyclonic storms could finally penetrate into central and upper portions of the drainage basin. Prior to 7,000 yrs. B.P. the blocking effects of the ablating ice sheet were reduced, which greatly weakened the summer's westerly circulation pattern and allowed for the deep penetration and mixing of both polar and tropical air masses (Knox 1983; Vento and Rollins 1989). This mixing effect, and the ability of tropical low pressure centers to move north into the central and upper basin, promoted large cyclone induced downstream floods. The coarser texture of the sediment/soil package emplaced after 6,000 yrs. B.P. attests to larger more competent flood events. Clearly, in the extreme eastern and northern portions of the site (Trenches 8, 9, and 1; Figure 6-5) that greatest rates of vertical accretion occurred at this time.

FIGURE 6-7: EVOLUTION OF THE MIGRATING HOLOCENE STREAM AT MEMORIAL PARK



Source: Dr. Frank J. Vento, 1993

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In a manner similar to that acting on the western portion of the site, the remaining two buried A-horizons are associated with the warm-moist climatic conditions of the Sub-Atlantic and Neo-Atlantic climatic phases. For example, the Sub-Atlantic subage 2AB/2Ab horizons in Trench 2 and 1 are time equivalent with the 2Ab horizon in Trench 6 and 3 AB horizon in Trench 9 (Figure 6-4). Additionally, the Sub-Atlantic phase buried A-horizon dated from Trench 9 (2Ab) and the 4Abg horizon in Trench 8 (1,220 ± 70 yrs. B.P.) are subjacent and time equivalent (Figures 6-3, 6-5).

Northern Site Segment (Belt 4): Trench 10 was the only trench emplaced on what is best considered the active levee of the present river (Figure 6-4). Trench 10 was excavated to a depth of 6.42 m (21 ft) below ground surface. The encompassed time interval for over 6 m (19.5 ft) of deposition is 2,400 years, or roughly 2.8 m of flood plain aggradation per 1000 years. This age assignment is based upon a radiocarbon date of a feature (which contained several biface thinning flakes) encountered at a depth of 6 m (19.5 ft) below ground surface.

The stratigraphic profile from the ground surface to a depth of 3 m (10 ft) consists of three stacked solas of late Holocene age. The uppermost Ab horizon contains abundant Clemson Island artifacts and most likely dates to the warm and moist Neo-Atlantic climatic phase (ca. 1,100 yrs. B.P. to 700 yrs. B.P.). This Ab horizon is then underlain by a sandy loam, Bw horizon. An early middle Woodland projectile point was recovered from a firepit in this horizon. The next allogenic genetic unit or buried A-horizon is a 2Ab horizon which was encountered at .19 m below ground surface. This horizon, as well as the underlying 3Ab horizon, document brief periods of floodplain stability during the late Sub-Atlantic climatic phase. From a depth of 3 m (10 ft) to the base of the trench at +6 m below ground surface, the entire profile consists of a series of incipient A-horizons which are capped by coarse-grained flood events (C-horizons). Within Trench 10, channel lag deposits and the water table were encountered at 6.42 m (21 ft) below ground surface. The pedogenically immature soil sequence found in Trench 10 is clearly a result of its proximal channel position, which favored frequent overbanking over the last 2,000 to 3,000 years.

Figure 6-8 correlates the paleoclimatic intervals, fluvial events and genetic soil horizons preserved at Memorial Park. These are indexed by the radiocarbon dates derived from associated soil horizons.

Geoarcheological Context: Distribution and Preservation of Archeological Deposits

Well dated archeological deposits were present across all landform segments and in stratified contexts at the Memorial Park site. As noted, the primary criterion isolating time transgressive events across the landscape was the lateral position on the landform. Deposits grade younger with depth along a southeast to northwest transect (see Figure 6-1).

These trends would be expected to be mirrored in the lateral and vertical distributions of archeological deposits. To examine the correspondence between the three dimensional distributions of archeological loci and dated surfaces and soils, a series of maps and profiles were assembled from the composite data sets including the Phase II report (Neuman 1989), Phase III report (Hart 1993) and the present study. Soils, subsurface stratigraphies, and depositional events were synthesized primarily from this study while the bulk of the archeological data is derived from Hart (1993). The present investigations identified only isolated features, which could not be considered representative of spatial distributions; they were incorporated primarily to index vertical sequences. The archeological stratigraphy was reconstructed from Hart (1993) since no composite section was prepared for that report. Vertical (stratified) archeological data sets were superimposed on our reconstructed stratigraphy as well as that of the individual excavation blocks as profiled (Cremeens 1993: Figures A-1 to A-16) to insure appropriate contexts for data transfer. Spatial distributions were more easily transferred, as they are based on existing feature maps (chiefly Hart 1993: Figure 122).

Figure 6-8: CORRELATION CHART: PALEOCLIMATES, FLUVIAL SYSTEMS AND SOILS AT MEMORIAL PARK

YEAR B.P.	POLLEN ZONATION		FOREST TYPE	CLIMATIC CONDITIONS	FLUVIAL ACTIVITY	GENETIC HORIZONS AT MEMORIAL PARK	RADIO CARBON DATES
500	PACIFIC	C3b	SPRUCE PINE RISE	COOL MOIST TO COOL DRY	ALLUVIATION	UPPERMOST SOIL SOLA	
1,000	NEO-ATLANTIC	C3a	OAK HEMLOCK CHESTNUT	WARM MOIST	FLOODPLAIN STABILITY	Ab	← 1200B.P. (Tr9) ← 1220B.P. (Tr8)
1,500	SCANDIC	C3a	OAK HEMLOCK CHESTNUT	COOL MOIST	ALLUVIATION	Bwb/C	
2,000 2,500 3,000	SUB-ATLANTIC	C3a	OAK HICKORY	WARM MOIST	FLOODPLAIN STABILITY	Ab	← 2030B.P. (Tr4) ← 2400B.P. (Tr10) ← 2920B.P. (Tr2)
3,500 4,000	SUB-BOREAL	C2	OAK HICKORY	PRINCIPALLY WARM-DRY	SEVERE TO MODEST LATERAL CHANNEL MIGRATION (SMALL TRIBUTARIES) WITH ALLUVIATION DOMINANT OVER INCISION ALONG MAJOR TRIBUTARIES	Bwb/C/AB	← 3590B.P. (Tr1)
4,500	ATLANTIC	C1	HEMLOCK LOWEST FREQUENCY	WARM MOIST	EPISODES OF BOTH FLOODPLAIN STABILITY AND ACTIVE LATERAL CHANNEL MIGRATION, INCISION AND AGGRADATION	Ab	← 4800B.P. (Tr9) ← 4930B.P. (Tr8)
5,000						Bwb/C	
5,500 6,000			OAK HEMLOCK			Ab	← 5410B.P. (Tr2) ← 5710B.P. (Tr5)
6,000						Bwb/C	
6,500						Ab	← 6990B.P. (Tr6)
7,000						Bwb/Bt/C	
7,500						Ab	← 8080B.P. (High Bank)
8,000 8,500 9,000	BOREAL	B	PINE OAK	WARM DRY	RAPID ALLUVIATION	Bwb/Bt/C	← 9250B.P. (Tr7)
9,500	BOREAL	A		COOL MOIST	MODEST ALLUVIATION	Ab	← 10210B.P. (Tr3) ← 10980B.P. (Tr4)
11,000 >11,000	PRE-BOREAL		TUNDRA/FIR/SPRUCE SEDGES/GRASSES	COLD PERIGLACIAL	ACTIVE LATERAL CHANNEL MIGRATION (LAG DEPOSITION)	C	

Spatial Distributions of the Buried Soils and Surfaces

A first step in this "mapping on" process was a spatial transposition of the buried surfaces correlated in the stratigraphic study (Figures 6-3 to 6-5). As discussed earlier, seven (7) geological units were identified in the composite sequence, each capped by a discrete soil that constitutes a period of stability and therefore a surface. The capping horizons were typically preserved as "Ab" horizons, although in several places the humic cover was stripped by erosion. Archeological sediments were most typically interdigitated within the humic horizons. Less frequently they occurred at the interface with the "Bw" or "Bt" horizon and even well within the complex of "B" horizons. In the latter cases a cumulic profile is represented (see discussion on site formation processes). The most representative situation, however, is that of a preserved, sealed cover solum ("Ab") horizon which was securely dated either by radiocarbon methods and/or by artifact assemblages and features.

Figure 6-9 is the baseline distribution of dated buried soils across the Memorial Park site. It is a two dimensional representation of the buried surfaces linked in Figures 6-3 to 6-5. As such this represents a plot of stable surfaces dominant across the landscape at fixed points in time. The oldest geological units are, expectedly, confined to the southwestern portion of the landscape (Soils 5, 6, and 7) and cover "Belt 1" and overlap into the central portion of "Belt 2". The very oldest soil--the Pleistocene gravels and "Bt" horizons--are represented by a single wedge on the extreme western periphery of the site. Early Holocene soils are strikingly absent, perhaps a function of the relative dynamism of the floodplain at this time; however deposits of this age have been dated on the western site margins in eroded beds of laterally accreted sands (see earlier discussion). Stabilization of soil environments begins after 7,200 B.P., during the Middle Holocene, as Soil 6 extends well into the center of the site. The soils and surfaces represented by these distributions correspond to the Paleoindian through Middle Archaic time periods. Examination of Figure 6-9 shows, however, that the oldest Soils (6 and 7) preserve stabilized surfaces across only 10% of the available site area. This corresponds to the Paleoindian and Early to Middle Archaic periods. It is only during Soil 5 times, that

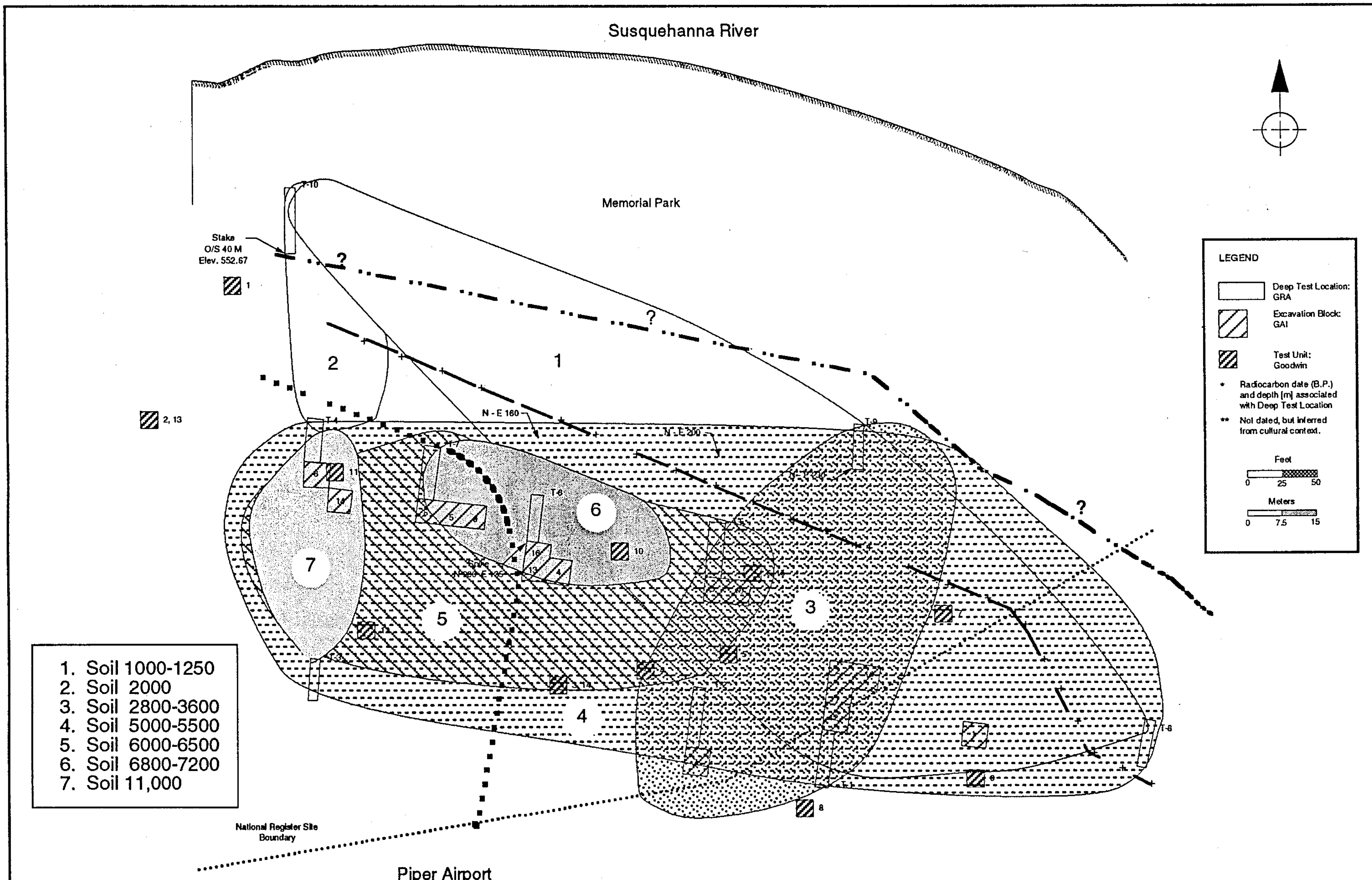

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Figure 6-9. Distribution of buried soils across the Memorial Park landscape

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more extensive and continuous surfaces of the landscape are opened up. Accordingly, during the terminal Middle Archaic and early Late Archaic about 35% of the terrain was available for occupation.

Soil 4 is the most extensive surface spanning the site, covering about 80% of the terrain. As discussed earlier, this surface registers the stabilization of landscapes across the southern portion of the site and is associated with the overbanking regime of the river and very limited aggradation in a stabilized channel. Contributions to the greater T-1 surface were markedly diminished after this time. The soil encompasses the extent of the Late Archaic occupation.

Soil 3 registers the areas subject to soil development in the Late Holocene. These are confined to the eastern and central portions of Memorial Park and account for 30% of the terrain. However, it is stressed that surfaces across the eastern and western segments of the site (i.e., those within the perimeters of Soil 4) were available for occupation at this time. The limited distribution of Soil 3 to the east represents the evolution of an evolving soil environment, while the older surfaces to the west and east remained stabilized. This is not the case to the north, where surfaces were still building up. Accordingly, Figure 6-9 shows that no new habitable surfaces were created. This is consistent with the cut and fill cycle initiated by the West Branch around 3,000 B.P. Soil 3 and flanking segments sustained the Terminal Archaic habitations at Memorial Park.

Finally, Soils 1 and 2 register stabilization of northern and western surfaces during the Woodland period. Soil 2 is represented only in the extreme northwest, but Soil 1 is the youngest prehistoric surface registered and it covers nearly 70% of the site landscape. This is the area of the Clemson Island component and documents successive aggradation of the emergent floodplain formed within the abandoned channel of the Middle Holocene stream. Soil 1 does not encroach upon the highest surfaces of the site to the south. As noted these had been stabilized by 5,000 B.P. and preserve only surficial veneers of sediment. It is noted that this map is best viewed as a general guide to site preservation and isolates only those assemblages optimally sealed in "Ab" horizons. Clearly, distributions of features and artifacts extend beyond the perimeters of the mapped soil and onto eroded surfaces and "Bw" or "Bt" horizons, as discussed below.

The disposition of buried soils across the landscape provides a broad indication of the preservation gradient in three dimensional space. Specifically, Figure 6-9 is a measure of the potential of any given segment of the landscape to preserve a particular component in ideal (i.e., "Ab horizon") context. An additional measure of preservation is the antiquity of "near surface" soils, since, as discussed in Chapter 1, the major tracts of the T-1 landscape are flooded only infrequently and many of the later archeological deposits may not have been exposed to extensive erosion. Figures 6-10 and 6-11 are plots of late prehistoric features and surficial anthrosols covering the Memorial Park site. It should be noted that historic sediments were deleted from this map, since they are dispersed across the site. However, the antiquity of the surficial deposits identifies the potential for encountering activity areas of specific ages and the changing sensitivity of the landform for preserving the record of terminal prehistoric occupation. It is also a guide for excavation strategies, outlining the depths at which the initial in situ occupations are likely to be encountered.

Figure 6-10 maps out an overflow chute that was one of the more prominent features in the late prehistoric and historic evolution of the landscape. It represents a flow line that emerged as the levee was breached in Clemson Island times and underscores the potential for flooding in the late prehistoric period. Figure 6-11 presents the distribution of surficial anthrosols, identifying the ages of the youngest prehistoric deposits. As noted, the Clemson Island component (Anthrosol 1) covers over 65% of the present surface. Anthrosol 2 is a Late Woodland soil that extends across 5% of the northwestern site area, and Anthrosol 3 seals in the deeper, stratified deposits of "Belt 1".

Taken together, Figures 6-9 and 6-11 index the spatial and temporal parameters of site expectation at any given location at the Memorial Park site. Collectively, they plot the vertical and lateral extent of prehistoric deposits of a given age. Thus Figure 6-11 offsets the youngest archeological sediments that are likely to be encountered in

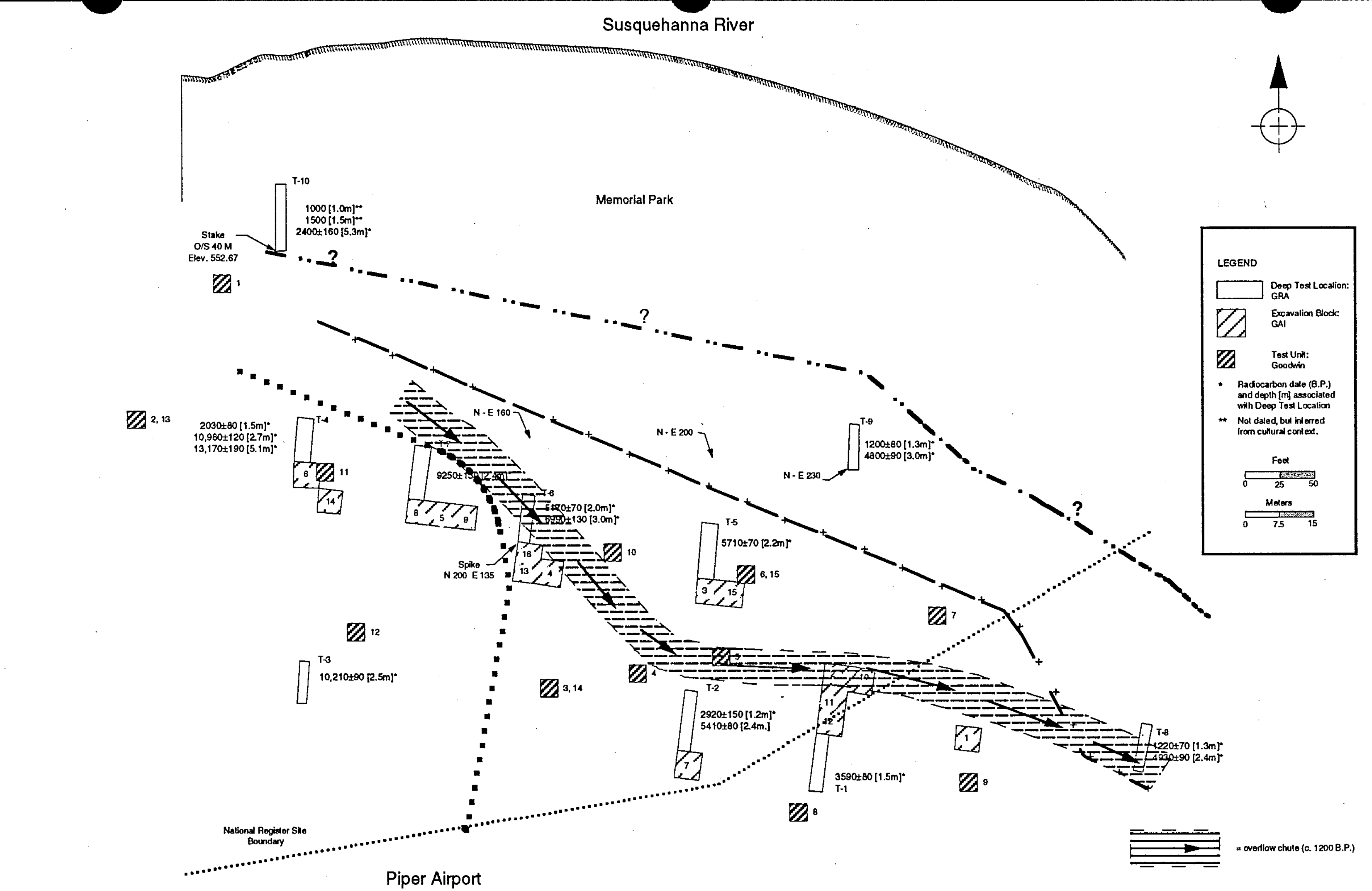

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Figure 6-10. Overflow Chute - 1200 B.P.

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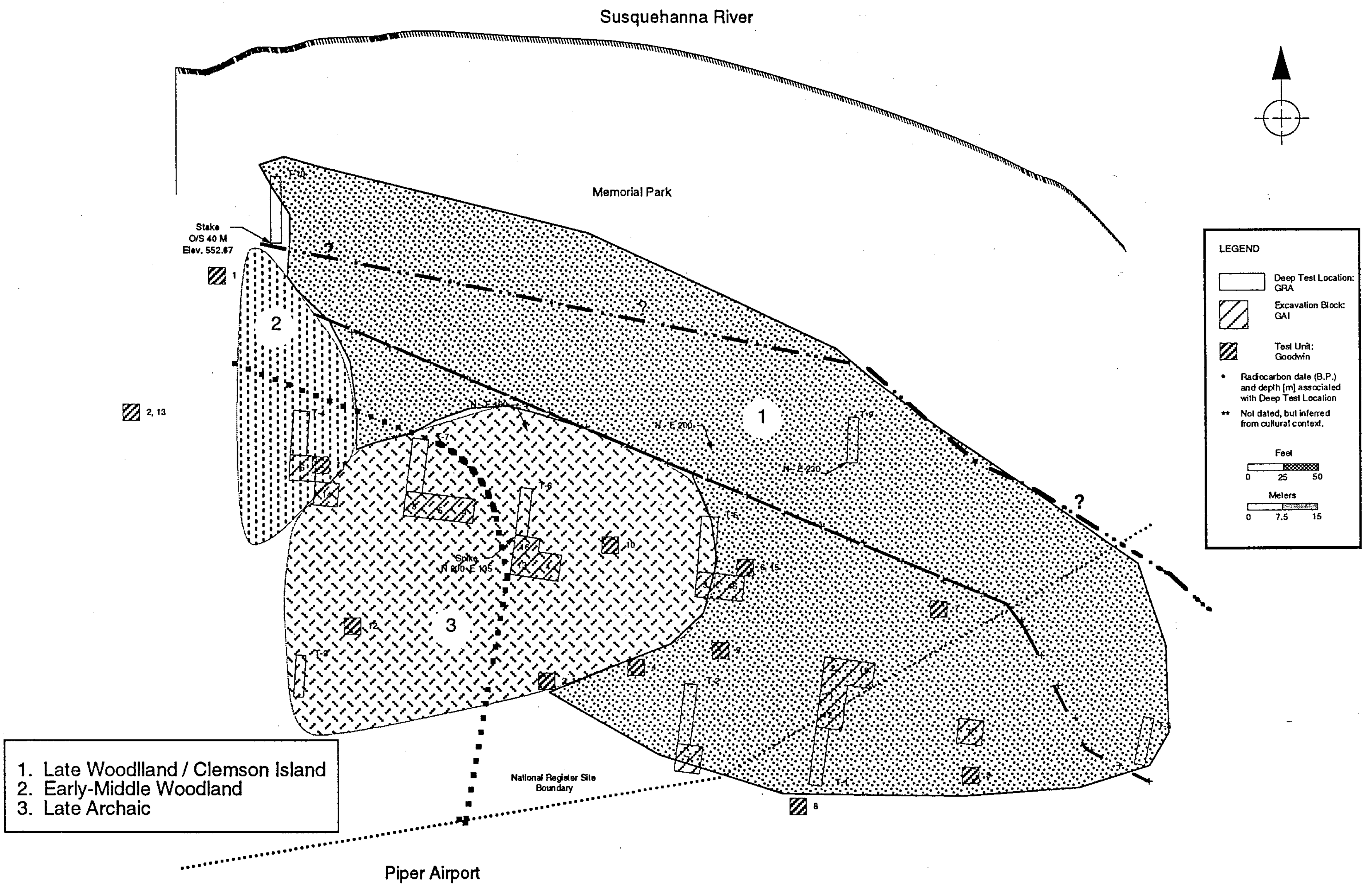

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Figure 6-11. Map of surficial anthrosols

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a discrete portion of the site, while Figure 6-9 provides the depth of potential stratification. For example, in the southwestern portion of the site potential Late Archaic through Middle Archaic and even older deposits may be preserved, while in the northwestern portion of the site only Clemson Island components are expected, since the plots of both the surficial anthrosols (Figure 6-11) and the map of buried soils (Figure 6-9) converge on the same component. The potential for deepest, oldest and most complete stratification is highest in the southwest, while in the east central portions of the site there is strong likelihood for Terminal Archaic through Clemson Island stratification (convergence of Figure 6-9, Unit 3 and Figure 6-11, Unit 1).

The validity of the "mapping on" of buried soils and surficial anthrosols to predict areas of stratification (Figures 6-9 and 6-11 respectively) can be tested by comparing the plots with vertically separated cultural stratigraphies. To perform this analysis, we drew upon the Block by Block inventories of vertical artifact distributions assembled by Hart (1993: Tables 2-8). These are the most complete (and only) records of component stratification compiled for the site. To insure intact stratigraphy we included only those blocks that preserved records in which each temporal component was separated from another by at least two culturally sterile layers. The individual blocks meeting these criteria were then linked to identify loci for individual buried components. The only components that were prominently stratified vertically were the Middle, Late, and Terminal Archaic. Figure 6-12 plots their distributions.

Comparison of the field distributions (Figure 6-12) with the soils map (Figure 6-9) shows a strong fit between the actual distribution of the occupations and the independently mapped time equivalent soils. Accordingly, the Middle Archaic locus is identified only on the northeast margin of "Belt 1" in Figure 6-12. The Middle Archaic age soil (Soil 6 in Figure 6-9) overlaps with the field distribution, although the latter also extends farther to the west and onto the older Pleistocene soil (compare Figures 6-9 and 6-12). The extension to the west may reflect preservation of Middle Archaic deposits on older, possibly truncated landforms and surfaces. For the Late Archaic it was demonstrated that surfaces were so extensive

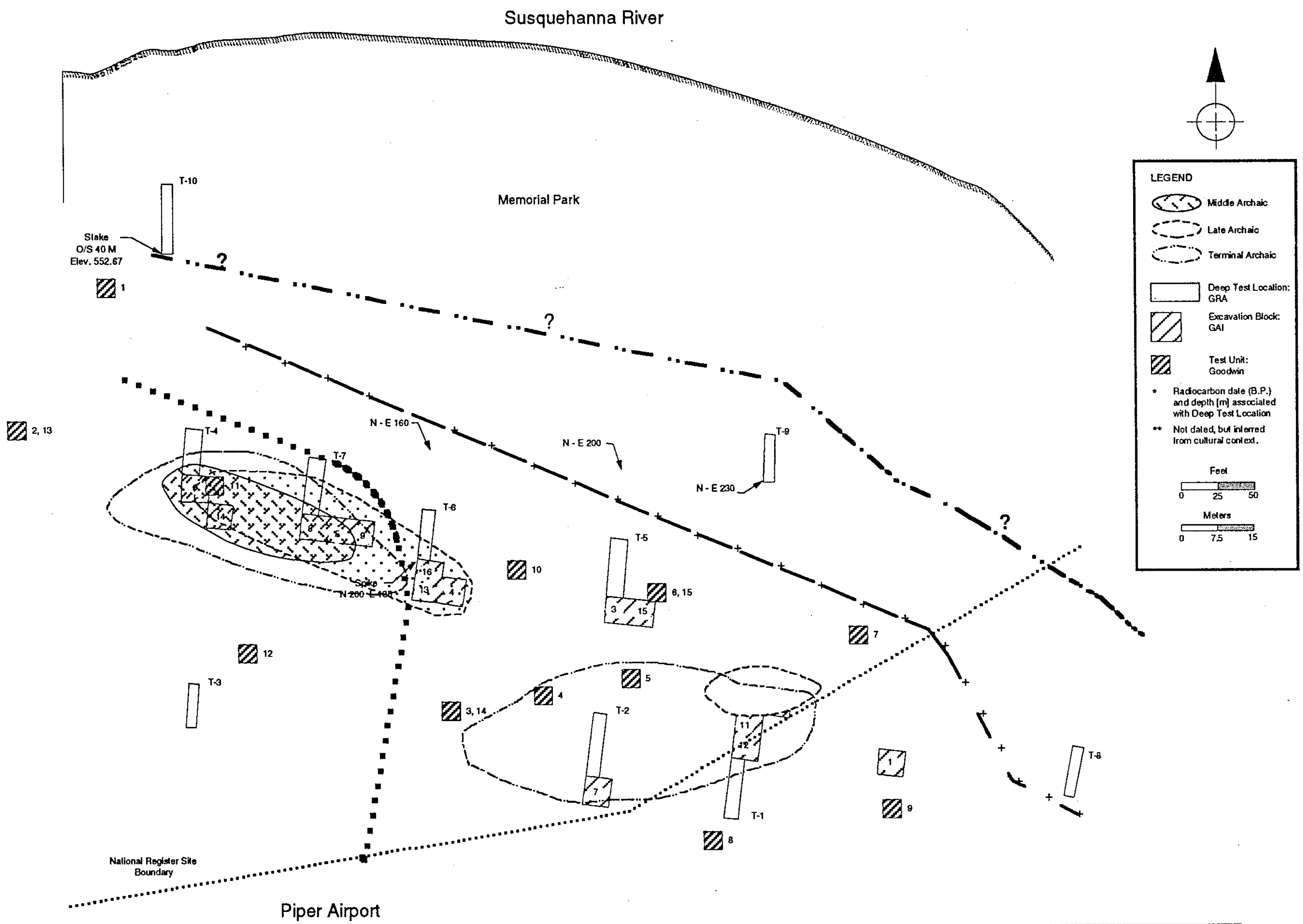

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Figure 6-12. Spatial Distribution of Stratified Archaic Occupations

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that preservation is likely at almost any location on the southern landform segments. Finally, for the Terminal Archaic, two loci are identified, one on the western portion of the site featuring the deepest stratified deposits, and, more interestingly, on the east-central site segment, where the deepest stratified Terminal Archaic deposits plot on directly with Soil 3 (compare figures 6-9 and 6-12). Finally, it should be noted that a calculation of the mean age of stratified deposits from the mapped loci produced an age of 4,639 B.P. for "Belt 1" and 3,360 B.P. for "Belt 2", confirming a trend to diminishing average component age along a northeastern gradient. This suggests that eastern migration of the landform was followed by the easterly shift in occupation loci.

The maps of soils and surficial anthrosols confirm archeological observations on site stratigraphy. Since only limited portions of the site were excavated, it is suggested that the combined models of buried and near surface archeological soils are useful predictors of component expectation across the differentiated landscape at Memorial Park.

CHAPTER 7: SUMMARY AND CONCLUSIONS

Geoarcheological investigations at the Memorial Park archeological site were initiated with the excavation of ten (10) backhoe trenches into stratified archeological deposits of the extensive first terrace (T-1) of the West Branch of the Susquehanna River in Lock Haven, Pennsylvania. Excavations disclosed a complex sequence of buried soils, surfaces, and alluvial facies, all of which articulated with diagnostic prehistoric components. Sixteen radiocarbon dates were utilized to index the late Pleistocene developmental history of the landform. A series of three detailed geoarcheological transects served as the baseline for integrating occupational and landscape histories. Additionally, a broad array of geochemical tests and analysis refined our understanding of the environments contemporaneous with and subsequent to the individual occupations sustained by the landscape.

It was recognized early in the study that the subsurface topography bore little to no resemblance to the contemporary near level surface gradients. A developmental model of site formation was generated that identified the southwestern segment of the landform as the oldest and most likely to preserve the earliest Holocene prehistoric deposits. Three dimensional reconstructions of buried soils and surfaces resulted in a model of decreasing landscape age in a northeasterly direction. A series of four (4) depositional "Belts" radiating outward from the oldest landform identified the progradation of landscape buildup in response to the migrations of the West Branch and its near channel landforms. Key turning points in landscape history were dated to 6000 B.P., when overbanking became the dominant depositional mode and sustained the Late Archaic and Terminal Archaic surfaces; and again at 3000 B.P. when a new cycle of cutting and filling established the Woodland age landscapes. A systematic reconstruction of the late Pleistocene through contemporary environments is presented in Figure 7-1.

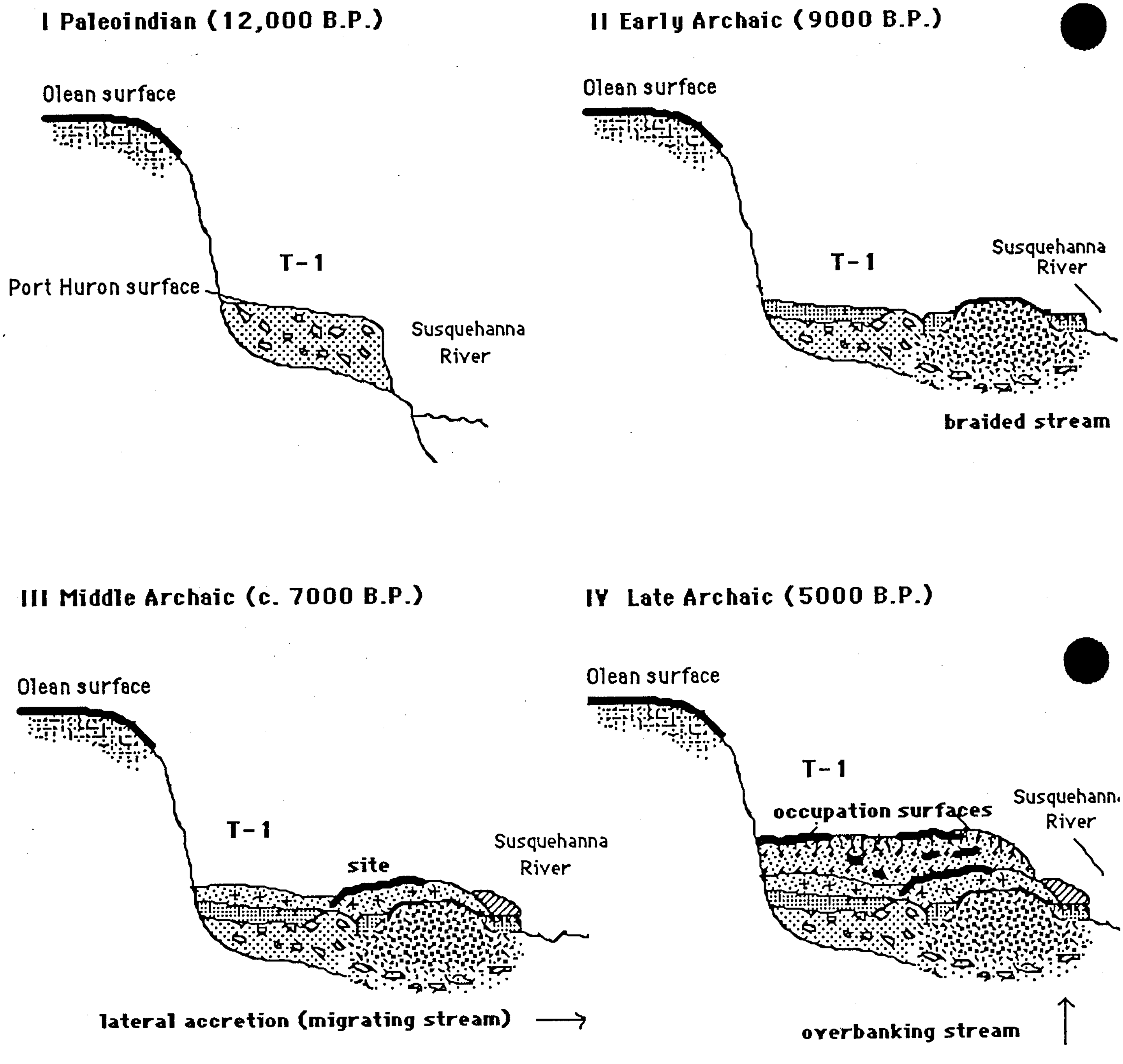

Figure 7-1a : Sequential Development of the Memorial Park Prehistoric Site Paleoindian to Late Archaic Periods

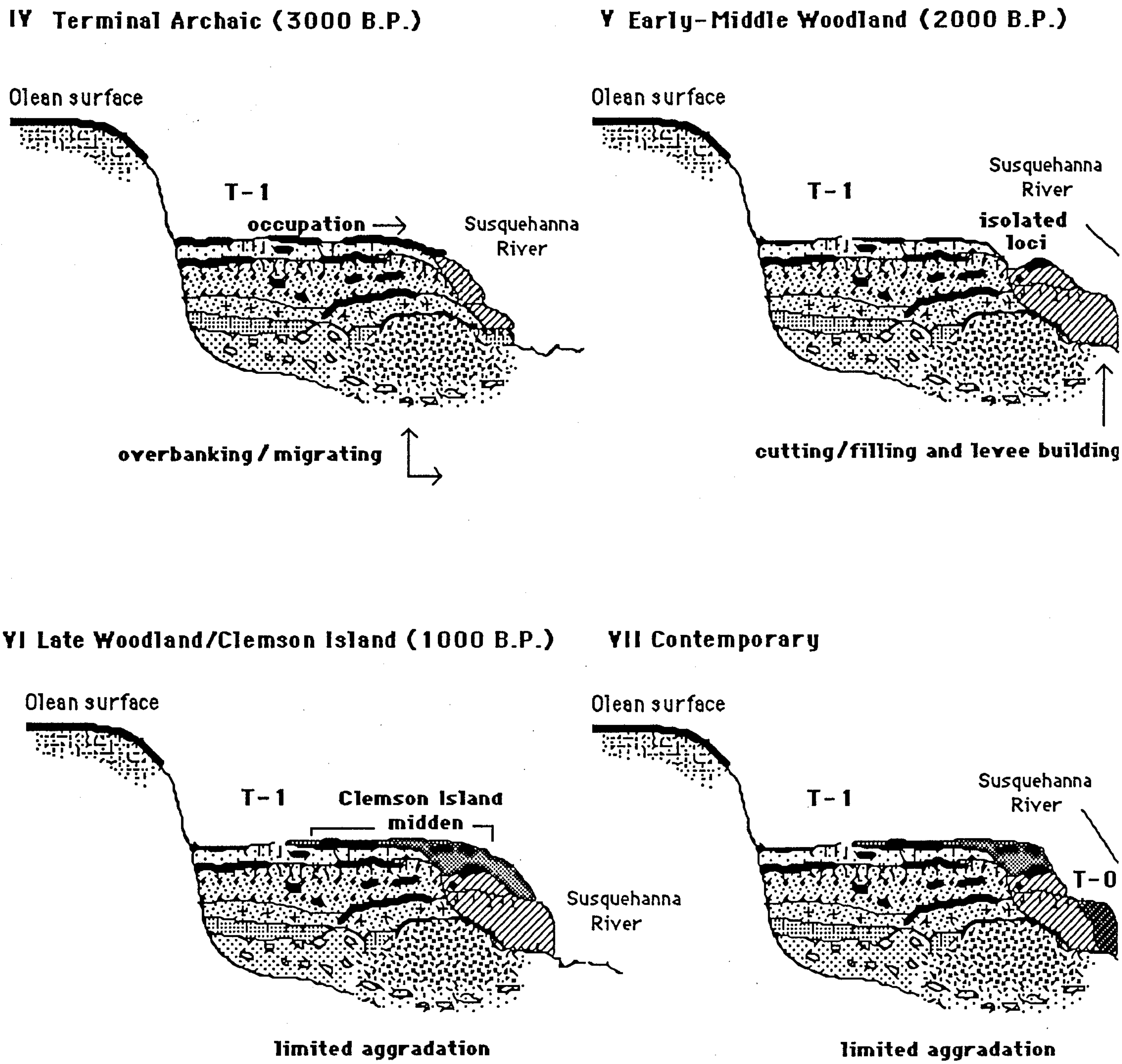

Figure 7-1b : Sequential Development of the Memorial Park Prehistoric Site Terminal Archaic to Present

It was possible to link the buried surfaces and soils with the extensive archeological distributions identified in earlier studies at Memorial Park. The correspondence between prehistoric landscapes and alluvial environments was facilitated by selectively utilizing the batteries of radiocarbon dates from previous work and incorporating them with the present stratigraphy. Ultimately a model of site expectation was generated across the differentiated site landform on a period by period basis. This model is presented in Table 7-1.

It is hoped that this study of site/landscape relations will provide baseline data for formulating regional models of human ecology in the Susquehanna basin and elsewhere across the northeastern United States.

Table 7-1: Geoarcheological Contexts and Preservation Potential for Archeological Components at Memorial Park

Prehistoric Period	Depositional Environments	Geoarcheological Context	Preservation Potential
Recent	Periodic alluviation associated with cultivation, airport construction and mechanical filling; limited erosion	Flood sands and isolated humic profiles ("A-C horizons") throughout site.	High: Belts 1,2,3,4
Historic (A.D. 1650-1920)	Historic cultivation	Base of historic plow zone (Apb)	Moderate: Belts 1,2,3,4
Late Woodland (1200-400 B.P.)	Anthropogenic environment with minimal floodplain or terrace construction (Soil 1)	Extensive sheet midden interdigitating with uppermost "Ab" horizon; variable 10-40 cm thickness everywhere, except where truncated by historic plow zone (Apb; see above) or where mechanically stripped	High: Belts 2, 3, and 4 Low: Belt 1
Middle Woodland (2000-1000 B.P.)	Transition from migrating stream to overbanking environment; Entisol formation (Soil 2)	To date associated with cumulic soils only (Ab/Bw interface or upper Bw horizons); linked to overflow chutes and channel migration	Moderate: Belts 3,4 Low: Belts 1,2
Early Woodland (3000-2000 B.P.)	Cut and fill environment as channel migrates to east; lateral accretion sediments (fining upward)	Diffuse throughout site. In older (western) landform segments associated with profiles developed on overbank alluvium. In eastern areas correlated with channel edge landscape (possible secondary context)	Moderate: Belts 2, 3,4 Low: Belt 1
Terminal Archaic (4000-3000 B.P.)	Continuation of overbanking regime (see below), but with limited buildup of surfaces to north (Soil 3)	Two clusters in western and southern portions of site; typically associated with cumulic profile (AB horizons) developed on channel edge overbank deposits of older landforms; overlooks middle Holocene channel	High: Belts 1 and 2 Moderate: Belt 3 Low: Belt 4
Late Archaic (6000-4000 B.P.)	Moderately anthropogenic environments. Uppermost (4500 B.P.) horizons register slow alluviation, initiation of stabilized channel and "upbuilding" of constructional floodplain; most extensive soil represented at site (Soil 4; Bw and Bt horizons)	Dominant in western portion of site with limited distribution on east; former levee locations overlooked northeast channel and overflow chutes to west; occurrence in "A" horizons as well as in "Bt" and "Bw" horizons in cumulic profiles	High: Belts 1 and 2 Moderate: Belt 3 Low: Belt 4
Middle Archaic (8000-6000 B.P.)	Upward fining sequences of migrating channel; lateral accretion deposits preserve thin solas that are widely expressed across the differentiated floodplain terrain	Preserved in soils of older west-central landform segment; stream deposits correlate with upward fining sequence and migrating channel	Moderate: Belts 1 and 2 Low: Belts 3 and 4
Early Archaic (10,000-8000 B.P.)	Bedded sands and moderate sized gravels; braided stream environment with channel migrating across floor; isolated soil forming pockets, invariably with eroded Bt contacts	Western portion of site only; channel fills and oldest overbank alluvium north and east consist of reworked Pleistocene sediments transported across channel floor	Low everywhere
Paleoindian (>12,000-10,000 B.P.)	High discharge gravels capped by bedded sands and/or Argillic paleosol (4 Bt horizon; Unit 7)	Channel gravels and organic lag deposits forming uppermost deposition of Port Huron terrace; western end of site only	Moderate/Low: Belt 1 Low: Belts 2, 3, and 4

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APPENDIX A

Appendix A: Granulometric Analysis Methods

For Trenches 1, 3, 7, and 10, granulometry of the sand fraction distribution was calculated for column profiles. These results are presented in Figures A-1 to A-6 following the collection and sampling methods described in Chapter 5. For the same samples, a series of grain size parameters were also calculated, These include the mean (Mz), sorting (So), skewness (Sk), and kurtosis (Kg). The strategy applied for calculation of parameters was the method of moments, following Friedman and Sanders (1978: 78-80). A synopsis of the method follows. Results. calculations, and graphic depictions for the grain size parameters are shown in figures A-7 to A-11.

Equations for the calculation of moments are as follows. The first moment of the method calculations is written as follows:

$$\text{first moment} = \frac{\sum f\, m\, \varnothing : x}{100} = \frac{\sum f\, m - \varnothing}{100}$$

Where f is the frequency for each class size and m o is the midpoint of each phi (x) class. The first amount equals the mean, (x). The second moment is a measure of dispersion about the first moment (x), and is expressed mathematically as follows:

$$\text{second moment} = \frac{\sum f\, (m\varnothing - x)^2}{100}$$

This second moment is the numerical value of the standard deviation squared. In order to obtain the numerical value of the standard deviation, we must take the square root of the second moment as follows:

$$o = \frac{\sum (f\, m\, \varnothing - x)\, 2}{100}\, 1/2$$

The standard deviation gives information on the extent to which sediment particle sizes are clustered about the mean, and hence defines the concept of sorting.
The third moment of the distribution is a measure of the symmetry of the frequency

curve about the mean and is written as follows:

$$\text{third moment} = \frac{\sum f\,(m\,\varnothing - X)^3}{100}$$

This moment is known as the 100 cubed deviation and, by rating the symmetry of the curves, determines its normality. Since $\underline{(m\varnothing - x)}$ is positive to the right of the mean and negative to the left of the distribution indicates is $\underline{O}$. A positively skewed distribution indicates an excess of fine particles to the left of the mean.

The skewness of the curve is commonly derived by dividing the mean by the cube of the standard deviation. This is expressed as follows:

$$\text{skewness } (O_3) = \frac{1 \times \sum f\,(m\varnothing - x)^3}{1000\ _{O3}}$$

Skewness, as the third moment reflects deviation from symmetry of the curve and is sensitive to the presence or absence of the fine or coarse fraction is a sample.

The fourth moment of the distribution is expressed as follows:

$$\text{fourth moment} = \frac{\sum f\,(m\varnothing - x)^4}{100}$$

The fourth moment is used to calculate the peakness (e.g., leptokurtic, mesokurtic or platykurtic) or kurtosis of the distribution. Kurtosis is calculated by dividing the fourth moment by the standard deviation raised to the fourth power, thus:

$$\text{kurtosis } (O_4) = \frac{1 \times \sum ff\,(m\,\varnothing - x)^4}{1000\ _{O}}$$

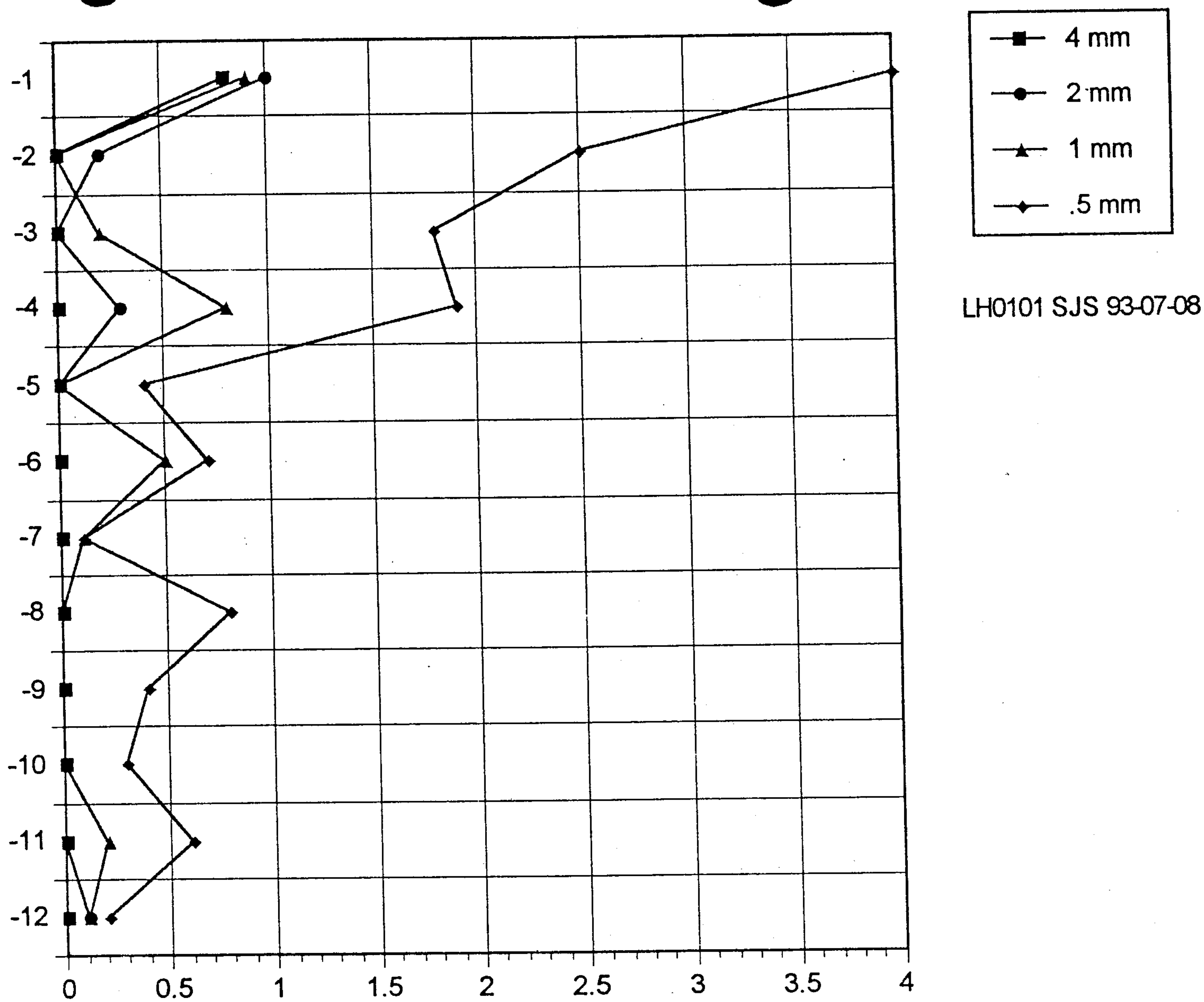

Figure A-1 Sand Fraction Distributions Trench1 Column 1

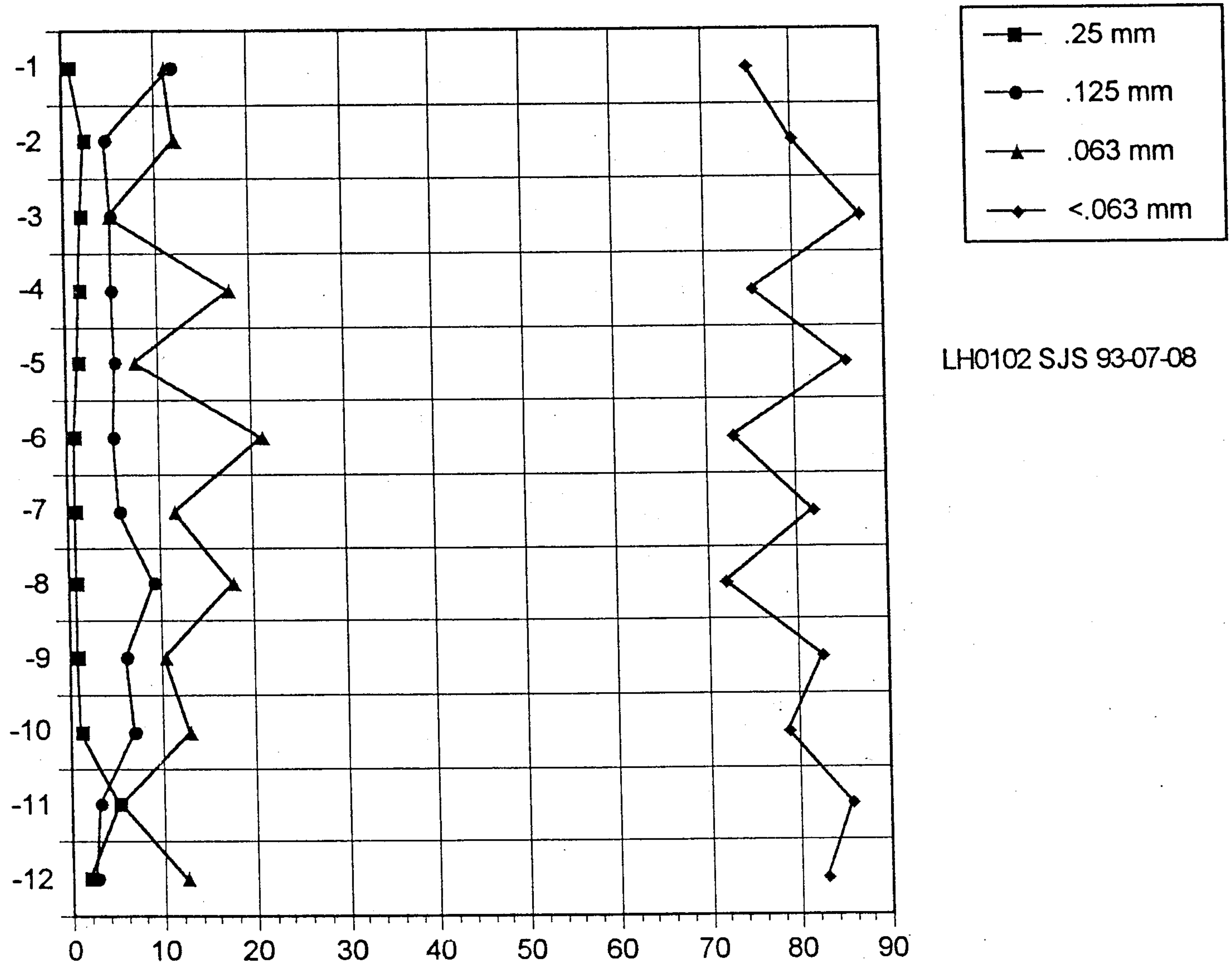

Figure A-2 **Sand Fraction Distributions Trench1 Column 2**

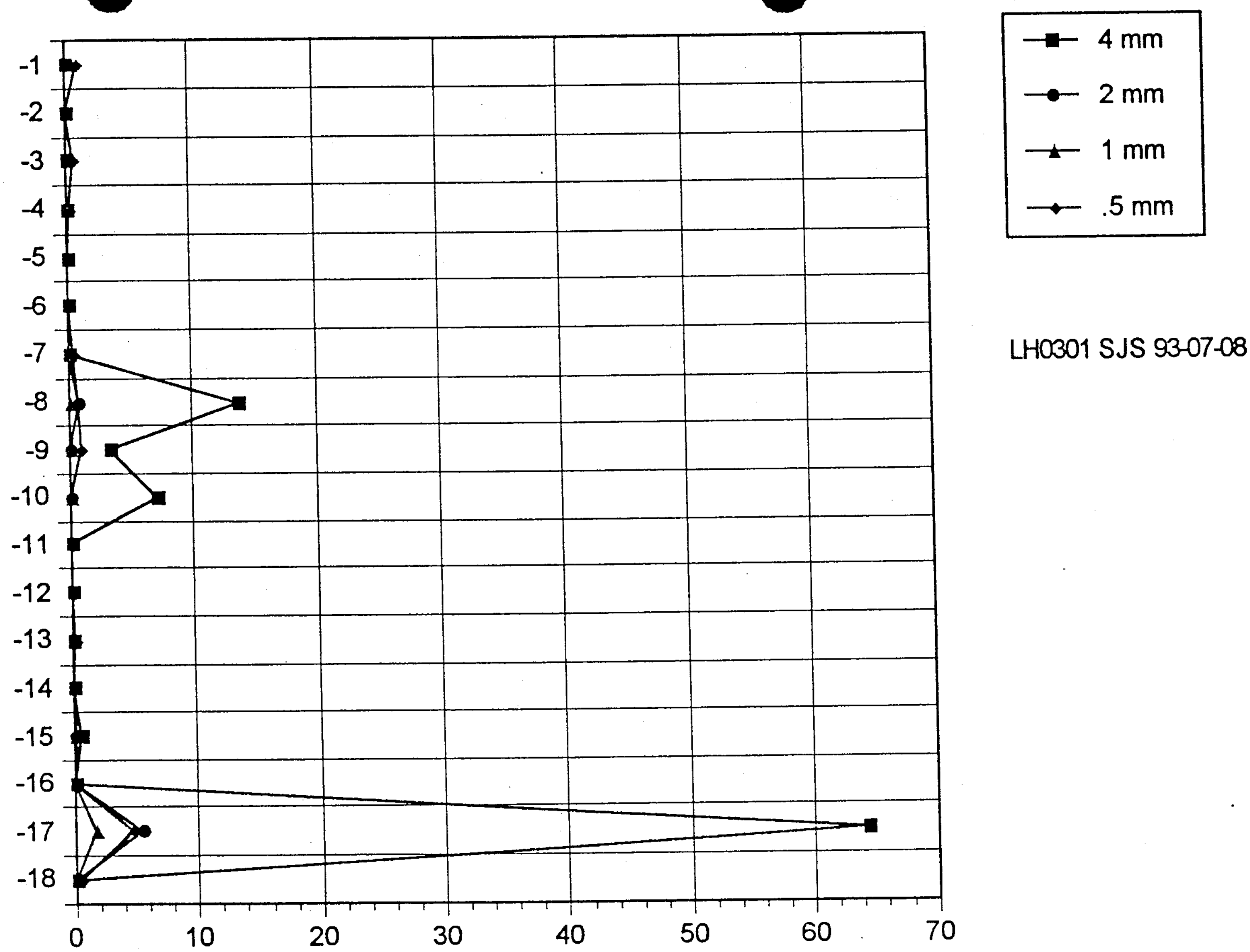

Figure A-3a Sand Fraction Distributions Trench 3 Column 1

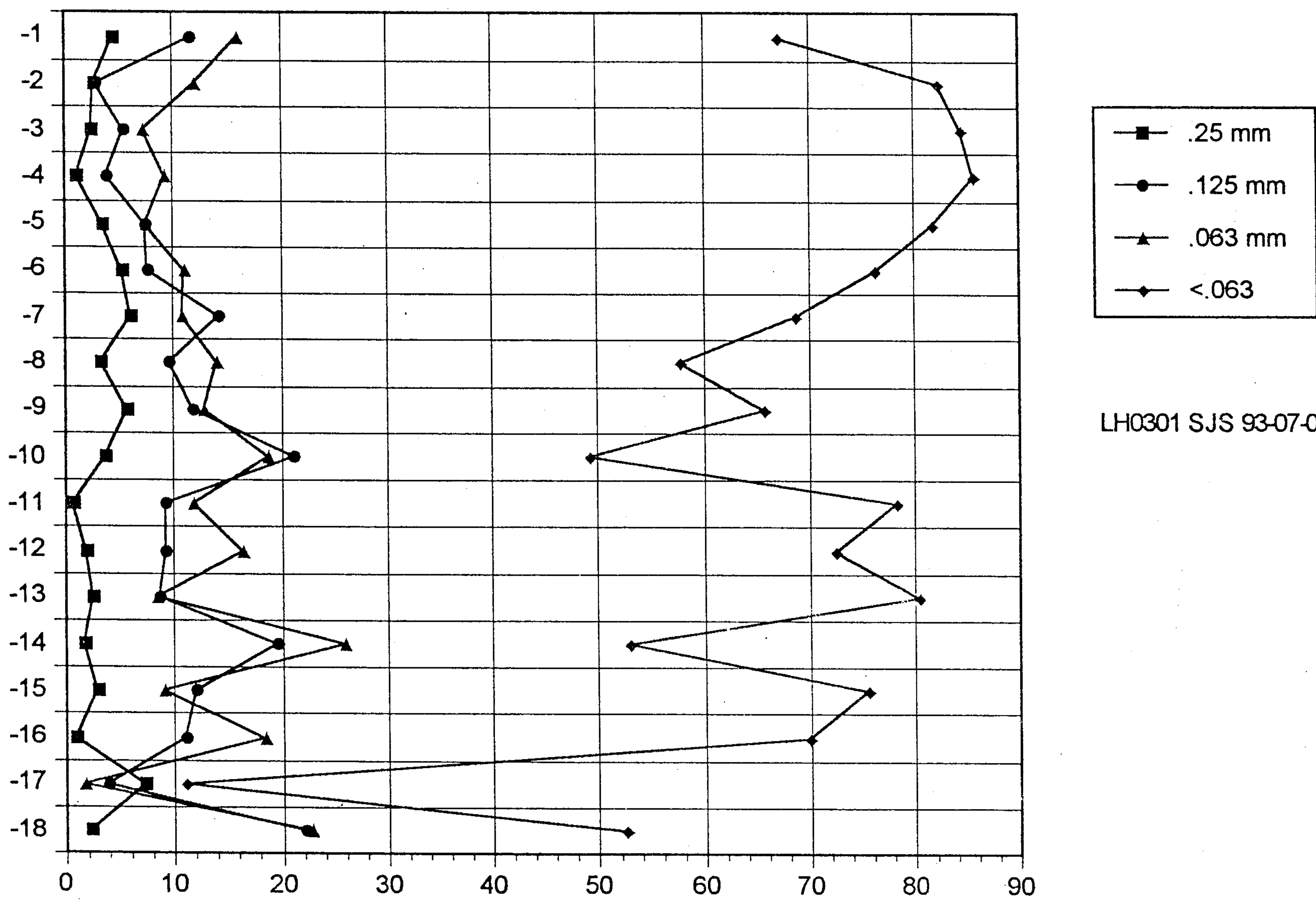

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Figure A-3b Sand Fraction Distributions Trench 3 Column 1

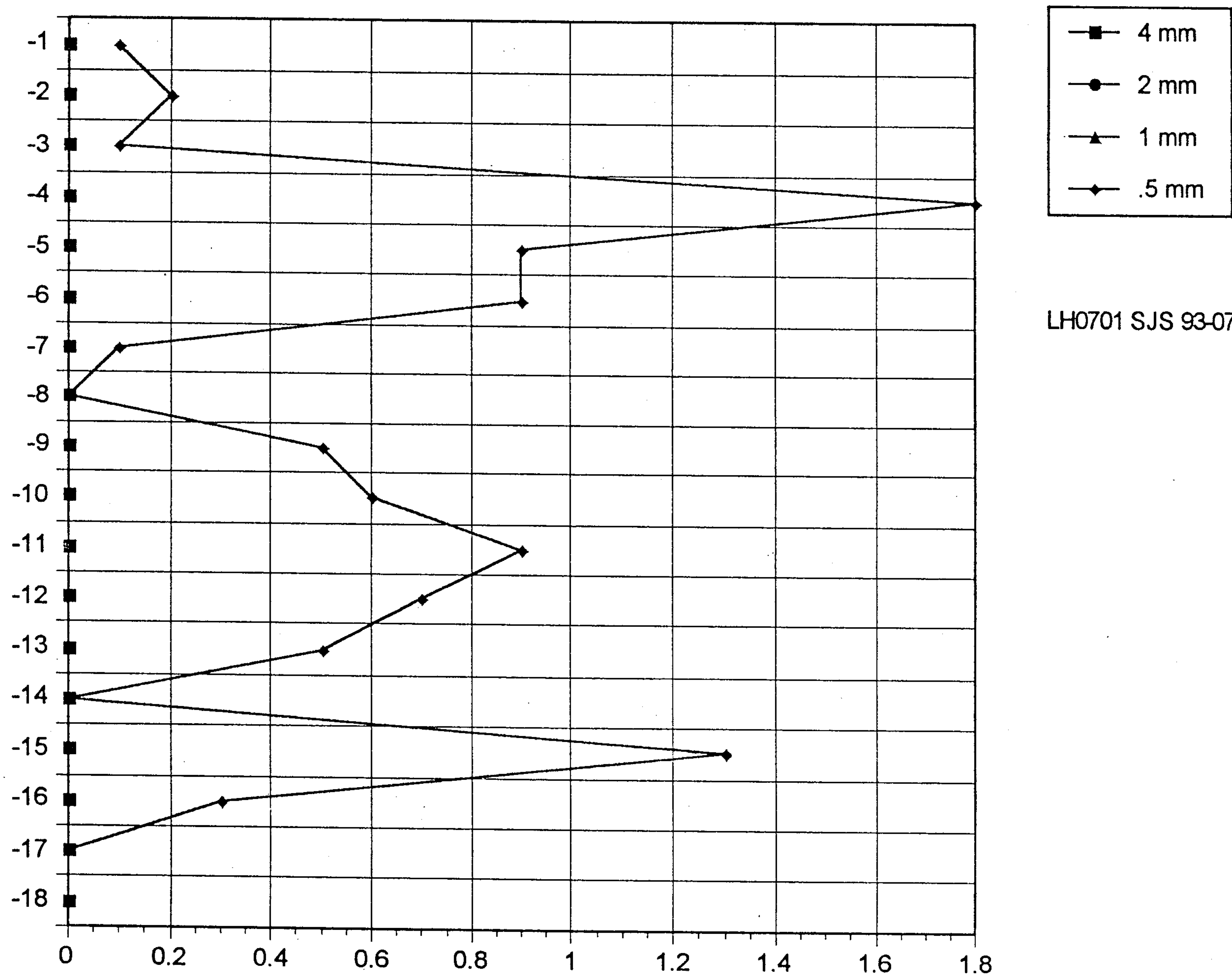

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Figure A-4a Sand Fraction Distributions Trench 7 Column 1

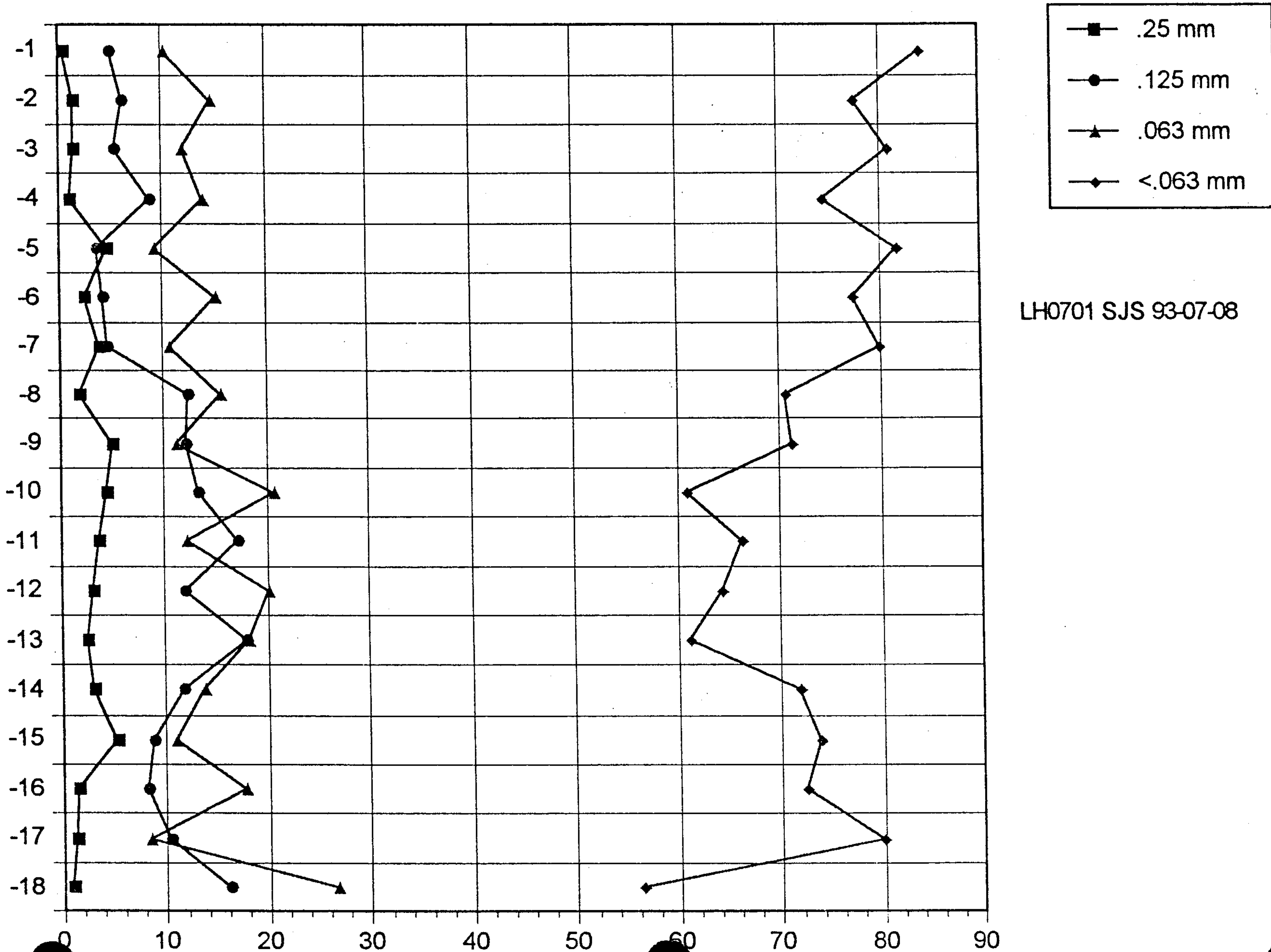

Figure A-4b Sand Fraction Distributions Trench 7 Column 1

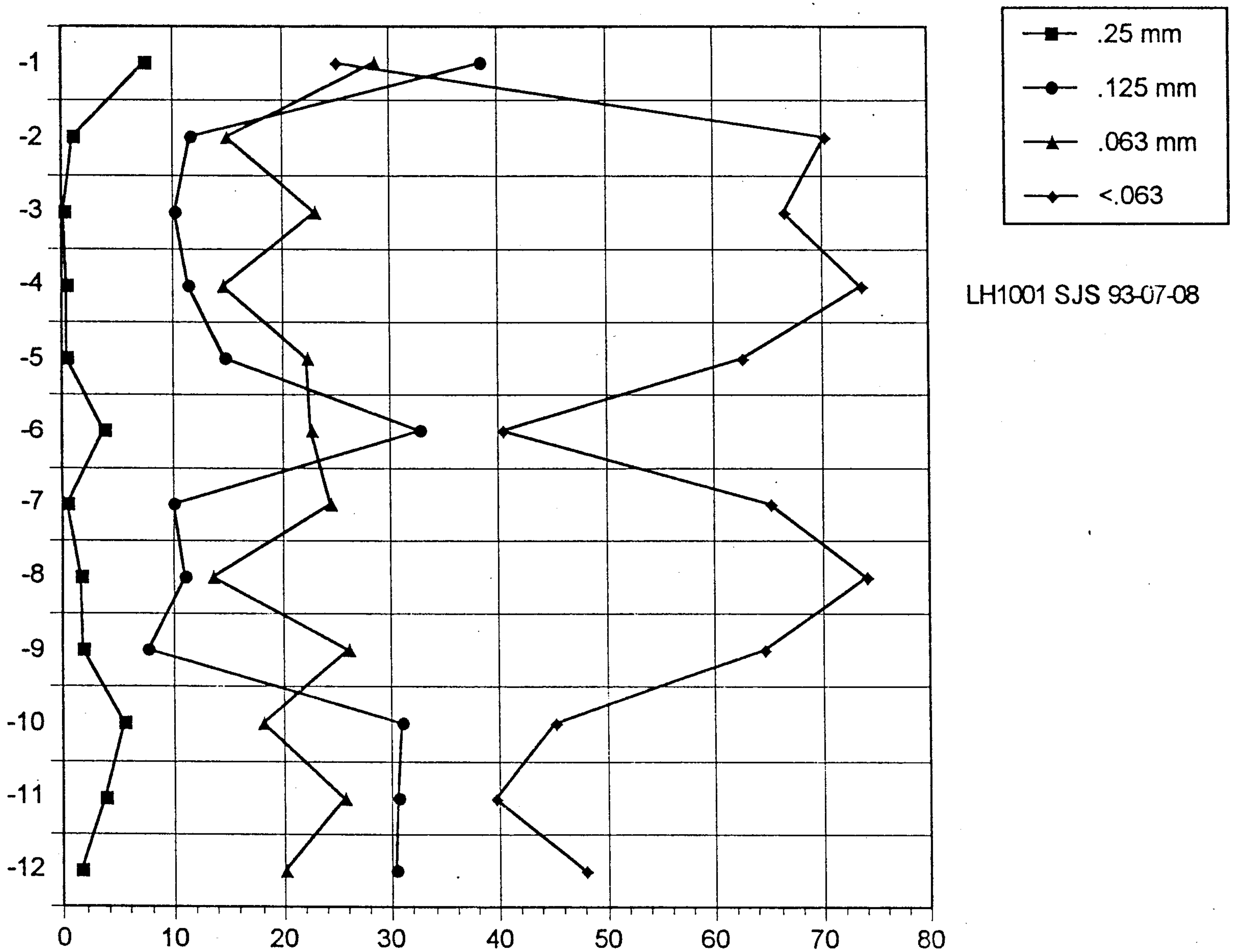

Figure A-5a Sand Fraction Distributions Trench 10 Column 1

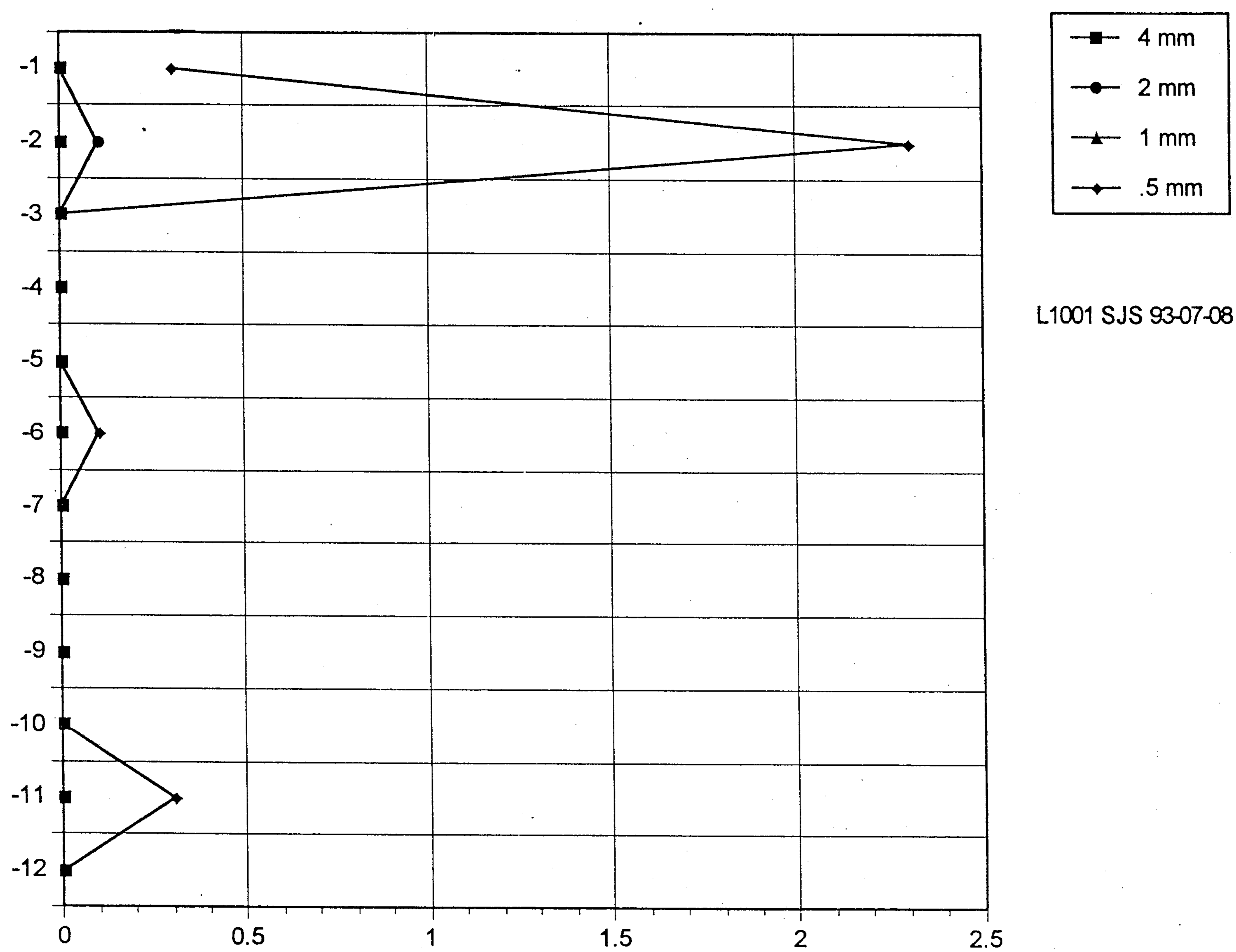

Figure A-5b Sand Fraction Distributions Trench 10 Column 1

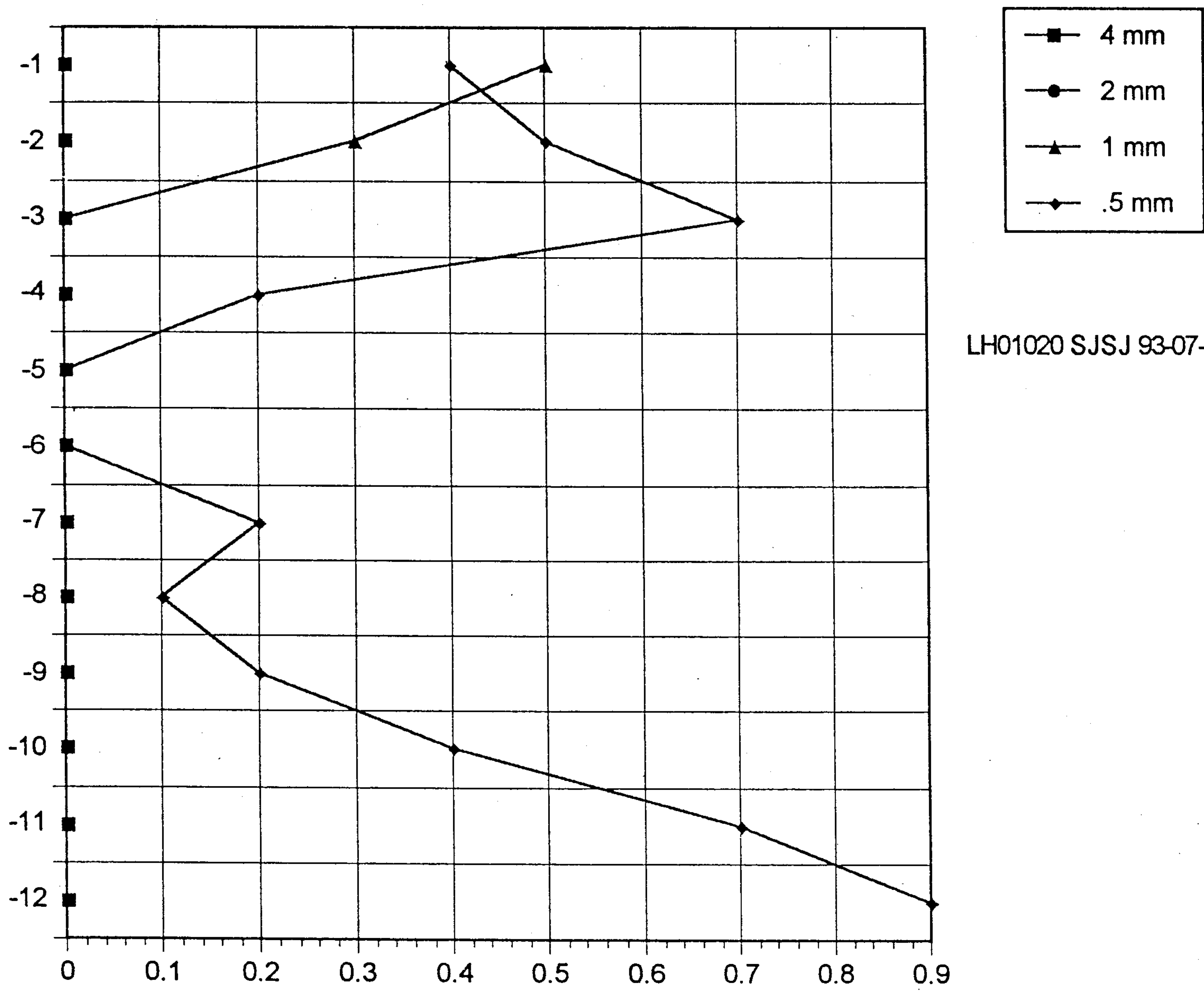

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Figure A-6 **Sand Fraction Distributions Trench 10 Column 2**

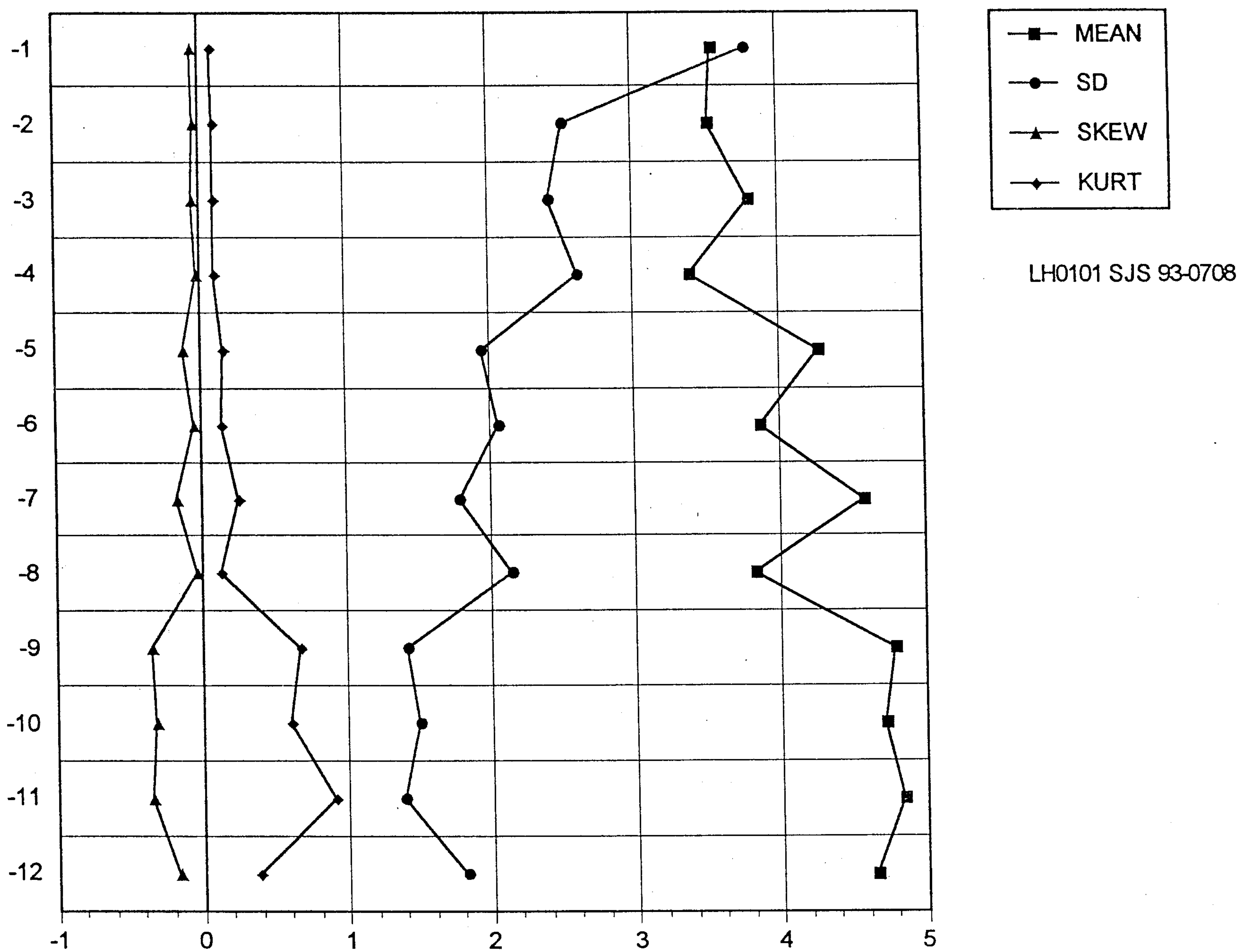


Figure A-7 Grain Size Parameters Tren[illegible] 1 Column 1

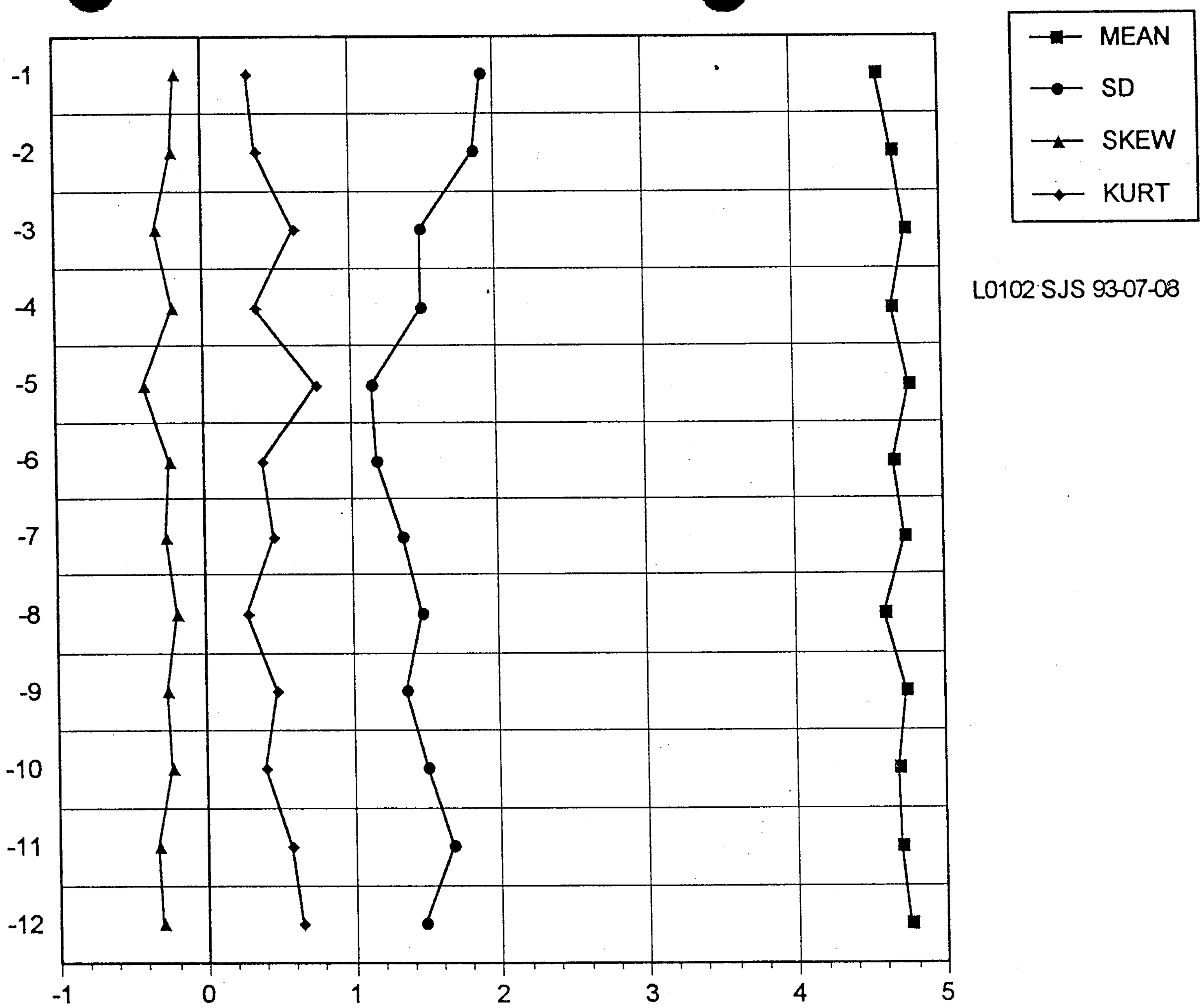


Figure A-8 Grain Size Parameters Trench 1 Column 2

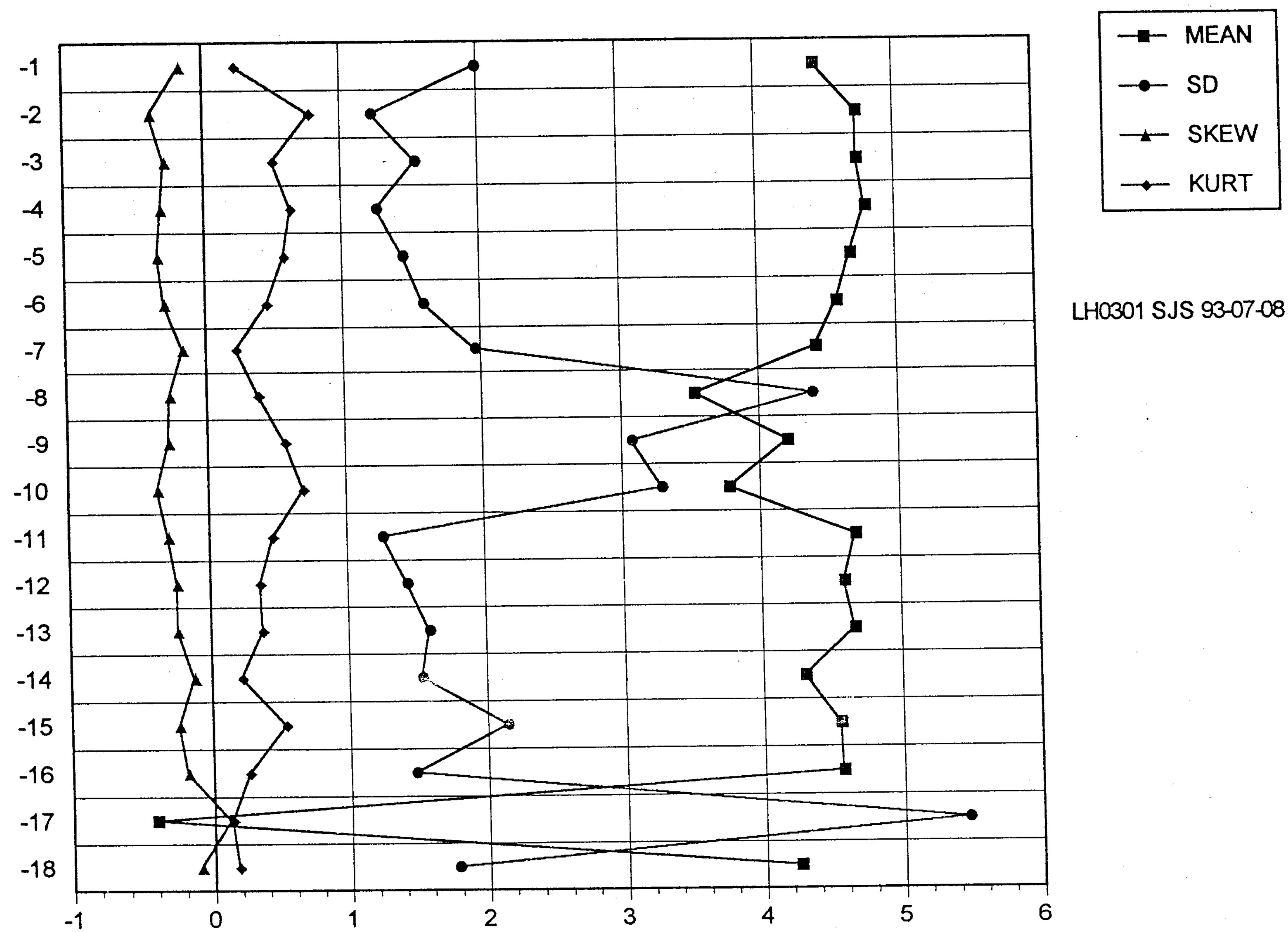


Figure A-9 Grain Size Parameters Trench 3 Column 1

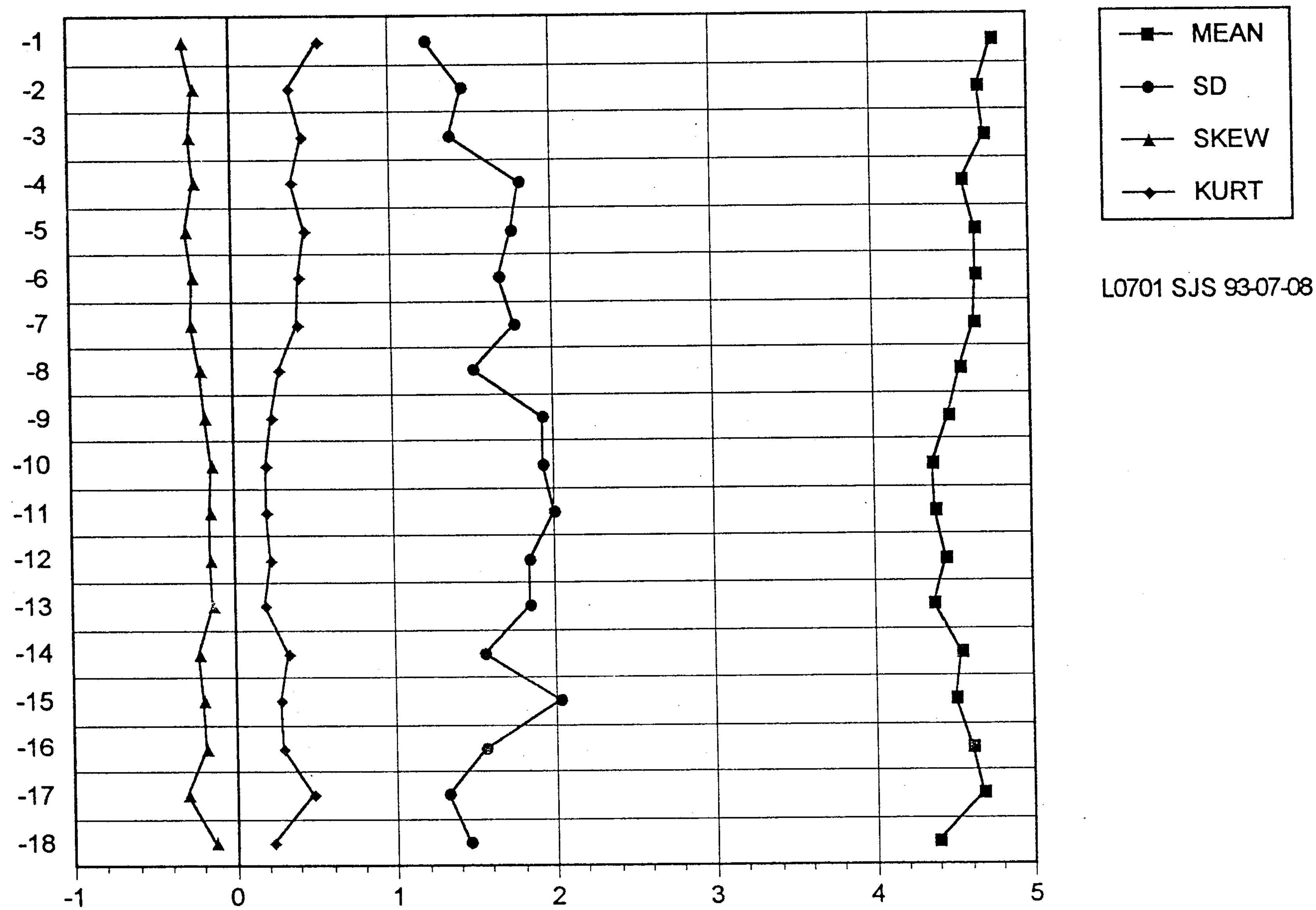


Figure A-10 Grain Size Parameters Trench 7 Column 1

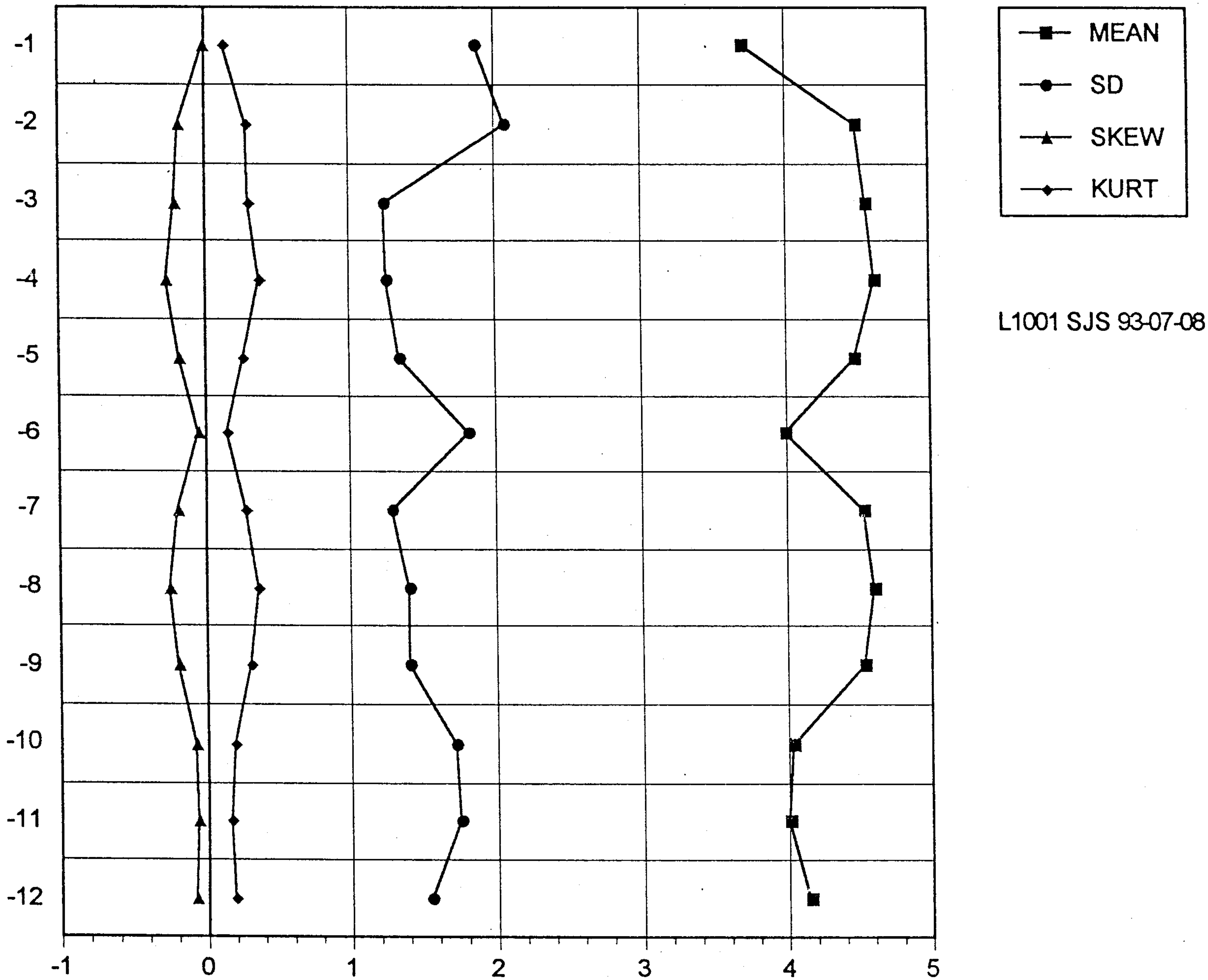


Figure A-11 Grain Size Parameters Trench 10 Column 1

APPENDIX B

Appendix B: Micromorphological Descriptions

Six standard size (27 x 46 mm) petrographic thin sections were prepared from impregnated, undisturbed blocks by Spectrum Petrographics, South Jordan, Utah. These were examined with a Nikon polarizing microscope in plane (PPL) and polarized (XPL) light, at magnifications ranging from 20x to 200x. Semiquantitative estimates of some of the components were based on visual comparisons with abundance charts published in Bullock et al. (1985); micromorphological nomenclature also follows this source.

Each of the six specimens is described sequentially and by soil horizon.

T-2: Ab [Plate B-1]

The coarse fraction is quite uniform and characterized by:

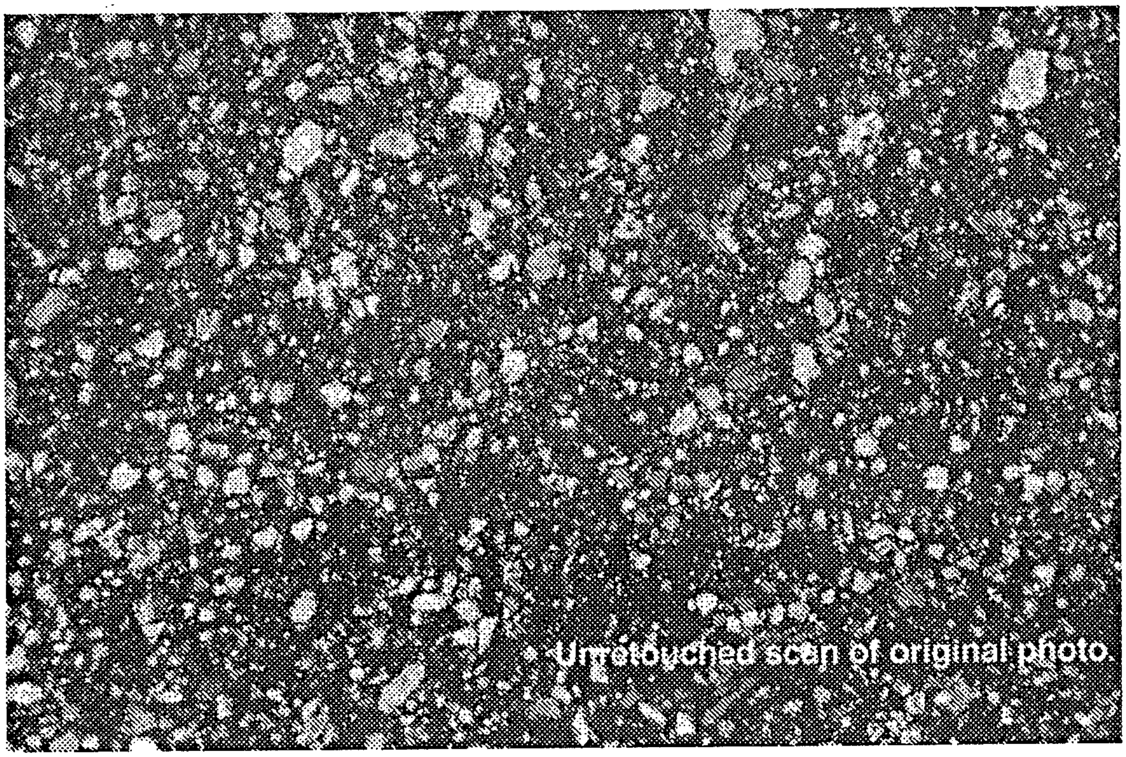
* angular to subangular medium quartz sand (~250 μm in diameter) (~1 - 2%);
* angular fine quartz sand and coarse silt (40-80 μm) (~30 - 40 %);
* Traces (<1 %) of sand charcoal.

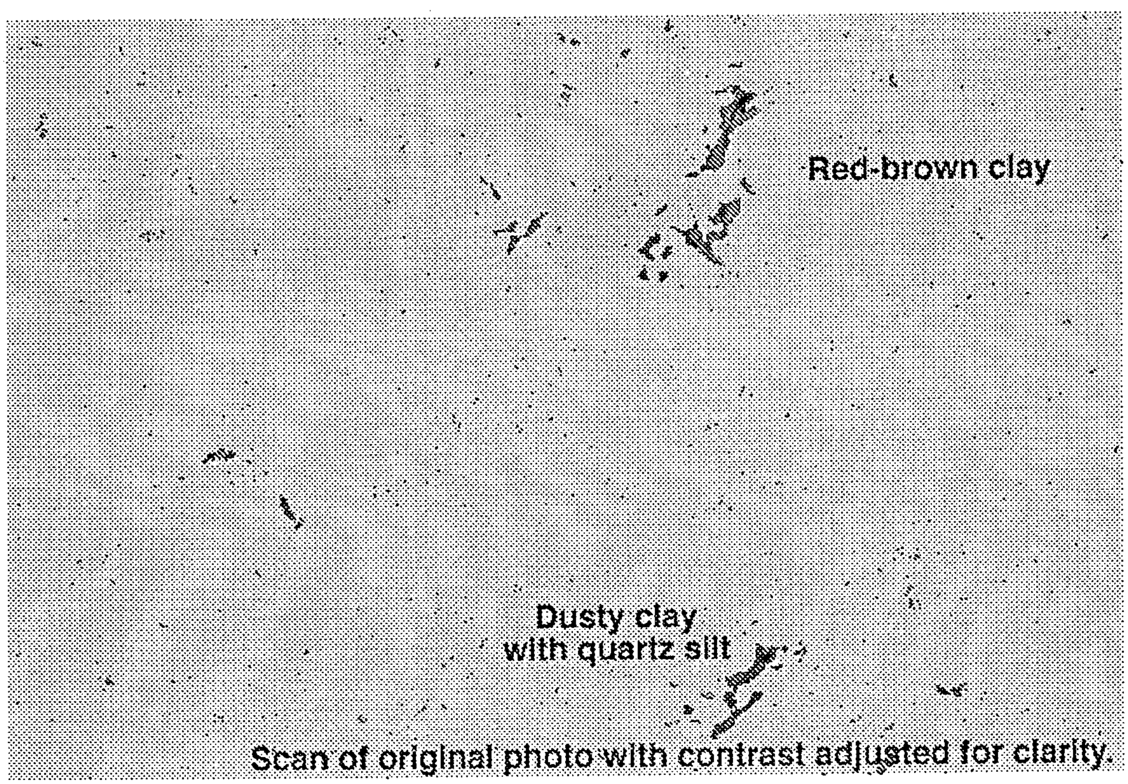
Also occurring in trace amounts are sand and silt size grains comprised of heavy minerals (undifferentiated); dark reddish brown to black clayey iron concretions with inclusions of quartz silt. All are well integrated into the matrix.

The fine fraction is comprised of reddish brown clay mixed with silt size fresh and weathered mica (~ 50 %). It exhibits a weakly developed speckled birefrigence fabric (b-fabric). The porosity is very low (<2 %) and is represented by isolated vughs and vesicles; these are more abundant in the upper portion of the slide.

Pedofeatures are expressed by reddish brown dusty clay infillings which exhibit diffuse to sharp extinction. Locally, similar material appears as thin (~100 μm) stringers which appear to delineate the boundaries of passage produced by soil fauna. In areas close to these stringers, and possibly associated with them, the matrix is better sorted and has a "washed" appearance, whereby some of the interstitial finer clay has been elutriated.

Plate B-1





Photomicrograph of T-2, horizon 2Ab. Note infillings of red-brown clay (upper) and dusty clay with quartz silt (lower).

T-2: Bw

Overall, this sample resembles the overlying 2Ab, but there are some notable differences:

1) The medium quartz sand fraction is absent, but other, finer quartz fractions are identical;
2) Void fillings are massive and composed of very dusty coarse clay to fine silt; they are very similar to those produced beneath disturbed surface horizons;
3) Remains of finely laminated slaking crusts were observed. These tend to form on an open extant surface and were later buried by younger alluvium. Such crusts are common in flood plains;
4) The fine fraction is similar but the overall clay content is somewhat greater;
5) Porosity is greater in this sample (~5 - 10 %) , and is expressed as vertically oriented vughs and channels; and
6) Pedofeatures are better developed in this sample in the form of pedoturbation.

This is expressed as domains of darker, presumably organic-rich clays that are clayier than the surrounding matrix and are up to 3 - 4 mm thick and are ~10 mm long; they tend to be vertically oriented. These clay-rich domains are not clay coatings since they are not related to voids.

T-2: 2Ab

The coarse fraction is quite similar to that of the upper Ab and consists of:

* angular to subangular medium quartz sand (~150 - 250 μm diameter) (<1 %);
* angular fine quartz sand and coarse silt (40 - 80 μm) (~30 %);
* isolated grains (<1 %) of sand size charcoal.

Sand and silt size grains of heavy minerals also occur, as well as very fine sand/coarse silt size dark reddish brown to black clayey iron/manganese concretions; the latter are typically well rounded. These are well integrated into the matrix.

This sample is proportionally richer in fine fraction (~50 %), than in the upper Ab but is similar to that of 2Bw. It consists of reddish brown clay mixed with silt sized fresh and weathered mica. It exhibits a weakly to moderately developed speckled and locally parallel striated b-fabric.

The matrix again is compact, and porosity is low (~1 %), greater than in the Ab but less than in 2Bw. Vughs are the principal void type.

Pedofeatures consist of dusty dark brown clay void coatings (~40 - 140 μm thick) with diffuse to sharp extinction. These are more limpid and finer grained than in the overlying samples, and display better orientation of the clay; infillings are somewhat less prominent than above. Thin dusty clay stringers also occur, but "washed" areas are rare. In contrast, localized mm-size domains occur which are darker and more isotropic, probably due to inclusions of organic matter and possibly iron. Their elongated, almost tubular shape strongly suggest that they are passage features of biological origin.

T-2: 2Bw

This sample differs from the 2Ab in certain respects:

1) It is less clayey than the overlying sample, and the silt and sand size fractions appear to be better sorted;

2) Porosity is much reduced and only traces of voids can be observed; and

3) Remains of small voids (~100 - 200 μm) are commonly filled with reddish brown to dark reddish brown moderately oriented limpid to dusty clay.

Less abundant but prominent are vertically oriented stringers (~1-2 mm long by ~0.1 mm wide) of dark brown clay; these are clearly coarser than the reddish brown ones. In most cases, these two types of translocated clay do not occur together. However, in certain voids it can be seen that the more limpid reddish brown type pre-dates the dark brown dusty type. Although the significance of this "stratigraphic relationship" is not clear it is possible that the later, dusty phase is relatively recent in origin and tied to translocation associated with overlying horizons, since samples Bw and 2Ab exhibit this type of coating and infilling.

Interestingly, the fabric and pedofeatures in this sample are different from those in the Bw. This is expressed mostly in the very low porosity. In addition, this sample displays two types of textural pedofeatures whereas the Bw shows only the coarse, dark type.

Sample T-2: 3Ab

This sample is clearly more complex than the overlying ones. Proportions of components are different, and the fabric is considerably more intricate.

The coarse fraction is compose of the same bimodal distribution of quartz grains: angular medium sand (~250 - 500 μm) (~2 %), and angular fine quartz sand and coarse silt (40 - 80 μm) (~ 40 - 50 %).

The fine fraction consists of reddish brown clay mixed with silt size fresh and weathered mica (~35 %). The fabric is quite complex and varies throughout the slide. In most localities it displays a speckled b-fabric. However, in many areas of the thin section, the fine fraction has been depleted ("washed"). leaving domains of coarser, clay-poor silt as in sample 2Ab. When viewed at low power (18x) under a microfiche viewer (it was not possible to photograph this with the camera apparatus at hand), this arrangement somewhat resembles the so-called "branded fabrics" produced by freeze-thaw processes, although distinct bands are not discernible.

The matrix is compact, and with low porosity (~1 %), represented by regular vughs.

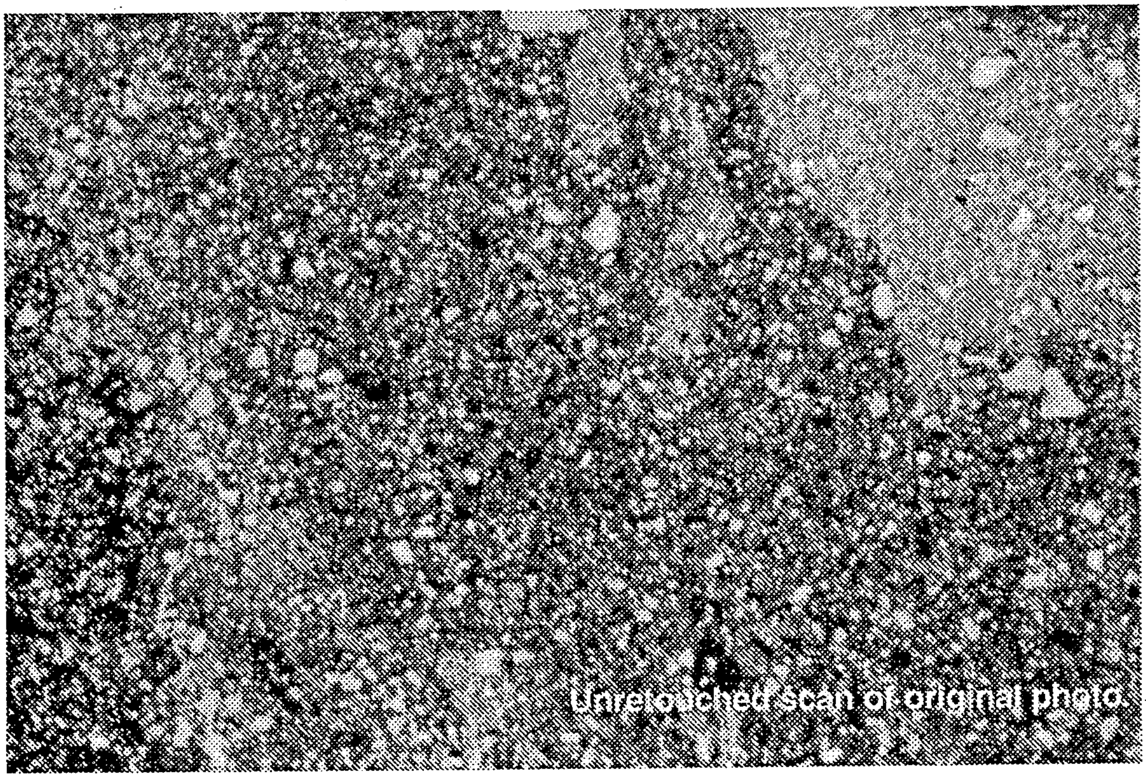
Pedofeatures are similarly more complex and more prominent. Three types of argillans are present that represent different phases of accumulation. The first type consists of deep reddish brown, pleochroic, slightly dusty clay which displays diffuse extinction. These occur both as void coatings and infillings, where they are well integrated into the matrix.

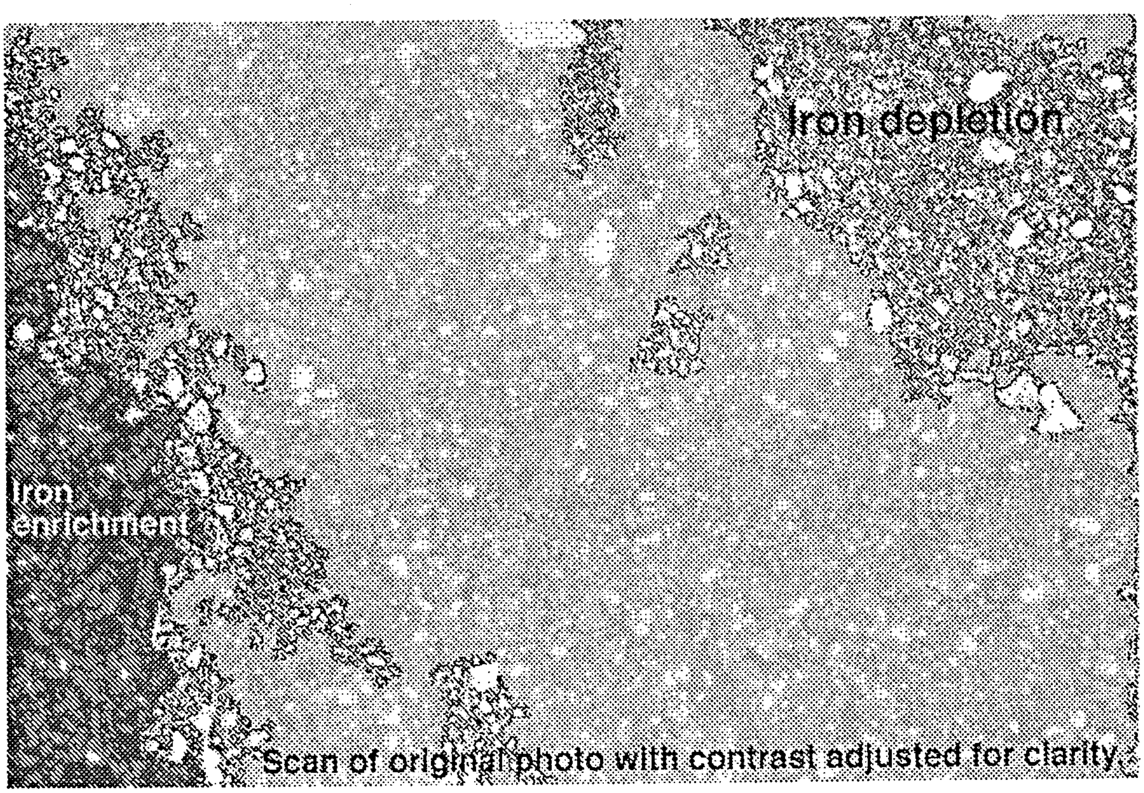
The second type is defined by very dusty, dark reddish brown void coatings and infillings intermixed with quartz silt. Juxtaposed and post-dating this type are the third type, comprised of dark brown to black quartz rich infillings; the dark color is presumably due to iron/manganese. This same material also locally impregnates the matrix (as in sample 2Ab).

Sample LH-2-3Bt [Plate B-2]

This sample displays both features that were observed above as well as those not observed previously. There is greater amount of dark brownish black, sand and silt size organic matter. Again, as in other samples, porosity is next to nil with virtually no observable void space. Features noticed previously include moderately well developed pleochroic, reddish brown, well oriented and laminated clay infillings. Several infillings of this type are followed or juxtaposed by a later

Plate B-2





Photomicrograph of T-2, horizon 3Bt. Gleying represented by zones of iron depletion (upper right) and enrichment (lower left). Note: minimal porosity.

infilling phase characterized by darker brown dusty lay with traces of quartz silt. The most prominent aspect of this sample are conspicuous signs of gleying, marked by lighter and darker zones that represent iron mobilization. Although some iron movement was shown in the overlying sample (3Ab), there it was expressed as last stage, localized impregnations.